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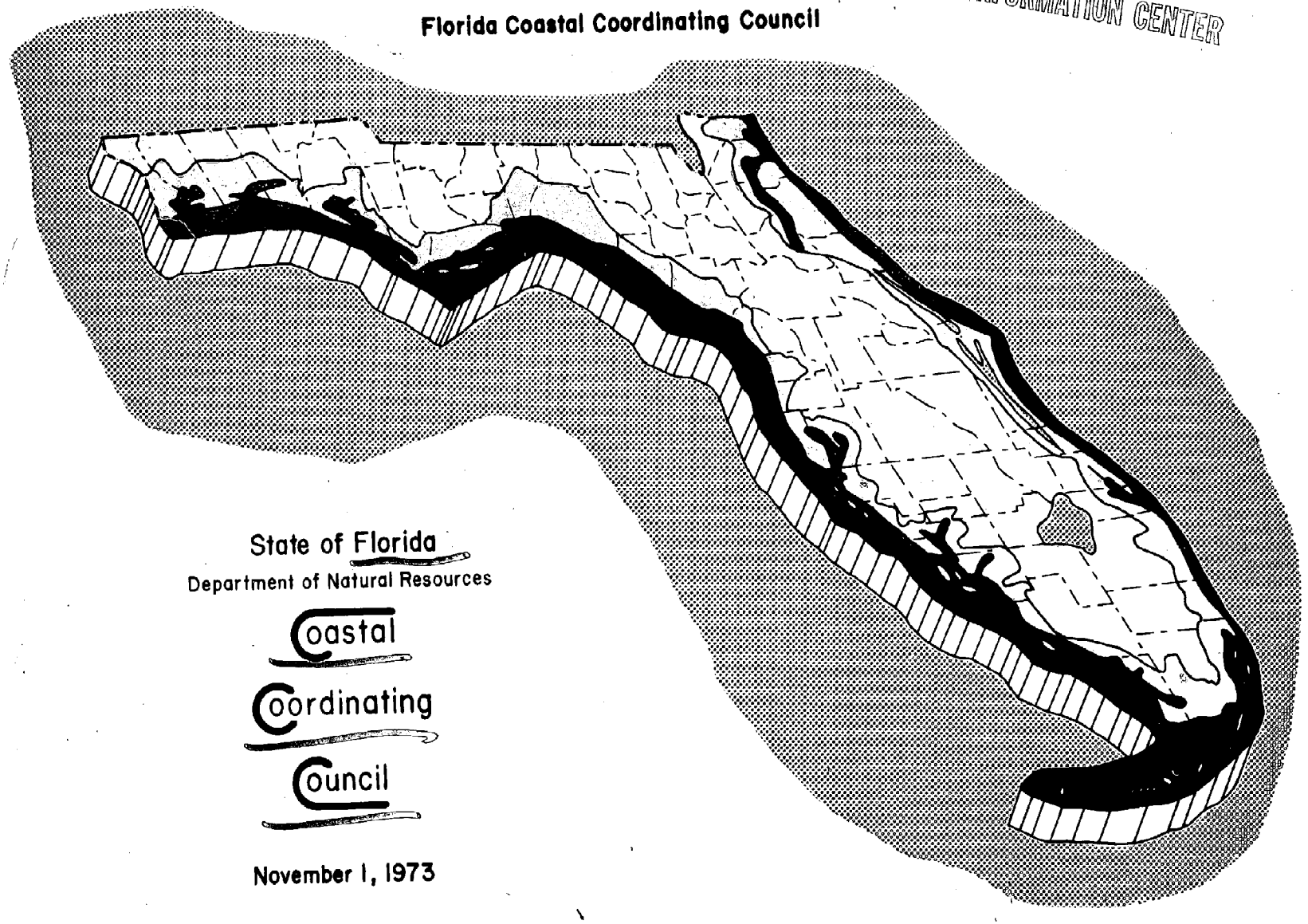
ESCAROSA I

AN OCEANOGRAPHIC SURVEY OF THE FLORIDA TERRITORIAL SEA OF ESCAMBIA AND SANTA ROSA COUNTIES

State University System Institute of Oceanography

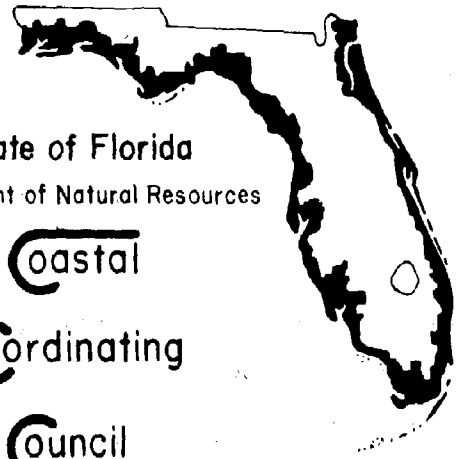
In Coorporation With The

Florida Coastal Coordinating Council



State of Florida
Department of Natural Resources
Coastal
Coordinating
Council

November 1, 1973



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ESCAROSA I

AN OCEANOGRAPHIC SURVEY OF THE FLORIDA TERRITORIAL SEA OF ESCAMBIA AND SANTA ROSA COUNTIES

A Report Compiled and Edited by
The State University System of Florida,
Institute of Oceanography
in cooperation with the
Florida Coastal Coordinating Council
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Preface

The 1970 Florida Legislature assigned the Florida Coastal Coordinating Council (FCCC) the charge "to develop a comprehensive state plan for the protection, development, and zoning of the coastal zone...". It was also given the assignment "to conduct, direct, encourage, coordinate, and organize a continuous program of research into problems relating to the coastal zone." To meet these charges, it was deemed appropriate to first analyze in detail a pilot study area, which characterized many of the coastal management problems typical of those found throughout the state.

The coastal zone of the counties of Escambia and Santa Rosa in the western panhandle of Florida, hereinafter referred to as "ESCAROSA", was chosen for such a pilot study because the region reflected the physiographic patterns of barrier beaches, lagoons, sounds, bays, and estuaries typical of many parts of Florida. The area chosen was of special significance to coastal management problems because it represented a prime example of multi-use conflicts between coastal zone resources, particularly industrial and chemical uses competing with tourism and commercial fishing. The basic outline for the coastal zone pilot study contained five parts:

1. The Biophysical Environment
2. The Cultural Characteristics
3. The Environmental Quality
4. The Coastal Management Plan
5. The Administrative System to Implement the Plan

The first three parts of the above outline are actually an inventory of the present situation at this point in time. The last two parts are the coastal management plan and the administrative system to implement it.

A preliminary survey of existing sources of information on all aspects of the Biophysical Environment of ESCAROSA established the fact that little was known of the oceanology of the territorial sea and that there were considerable gaps in the existing knowledge of marine ecology in both the estuaries and in the territorial sea.

In an effort to obtain significant elements of basic environmental knowledge concerning the oceanology of the territorial sea, the FCCC entered into a contract with the State University System Institute of Oceanography (SUSIO) to initiate an oceanographic survey during mid-September, 1971. The timing was propitious because the ESCAROSA I survey was to immediately follow a cooperative, interdisciplinary study of the Loop Current structure in the Eastern Gulf of Mexico (EGMEX). This study, EGMEX IV, the fourth in a series of continuing projects concerning the Loop Current structure, was conducted two weeks prior to ESCAROSA I. EGMEX IV operations were also combined with a major seasonal study of the physical, biological, and geological parameters of the Western Florida Continental Shelf. This seasonal study, called the Western Florida Continental Shelf Program (WFCSP), was based on a sampling pattern of 15-mile centers from the 10-fathom line out to the edge of the Continental Shelf. The significance of these programs is in their physical and temporal relationships to the ESCAROSA I operation, allowing the data to be analyzed quasi-synoptically and to provide a broad background in both time and space to better define the observed conditions in this region of the Eastern Gulf of Mexico. The typical expenditure for personnel, ship, equipment, data reduction, and analysis for a combined EGMEX-WFCSP is in the vicinity of $250,000. As planning progressed, a cooperative agreement with the Florida Department of Pollution Control made it possible to also take data from stations at the mouths of the Escambia and Perdido rivers and through their estuaries to the open sea. Thus, it was possible, within one limited time period, to measure and evaluate a variety of physico-chemical and biological conditions prevailing in the system extending from within the primary rivers of ESCAROSA through the estuaries, and finally, out into the Eastern Gulf of Mexico.

From a modest beginning, representing only an initial investment of $15,000 by the FCCC, the project grew, under the management of SUSIO, to include three state universities, one private university, four federal laboratories or agencies, two state laboratories, three private companies, and three state agencies. The total expenditure represented by this final report is probably in the vicinity of $150,000. It proved to be a model of intergovernmental cooperation aided by contributions from private enterprise. Many of the participants provided long hours of work and travel without compensation because they were vitally interested in the results.

The project was a pioneering effort in unifying regional oceanographic data so that discrete parameters could be traced within the same time frame, encompassing a system stretching from the rivers to the open sea. In so doing, it has documented the fundamental importance of repeating this experiment during other seasons of the year to

achieve an ability to effectively evaluate and predict characteristic phenomena of importance to objective coastal management decisions. Even within the limitations that ESCAROSA I represents: a single discrete series of samples from a limited time period; the fact that practically no data of these types previously existed makes the information unique and valuable. A number of significant coastal management conclusions may be drawn from the study. Probably the most important is that the estuary consisting of Escambia, Pensacola, and East bays is not flushed out into the Gulf of Mexico by tidal currents, and that the dominant influencing environmental attributes are derived from a westerly source, most probably from Mobile Bay outflow, or possibly from the Mississippi River. The implications of this should indicate to the people of the ESCAROSA region, and to the state and federal agencies, that it is absolutely imperative to control the pollutants entering these estuarine waters. This knowledge of the lack of flushing alone is well worth the cost of the study provided the knowledge is put to good use. It is certainly no wonder that this area is suffering from repeated and extensive fish kills and the death of valuable oyster beds.

The FCCC wishes to acknowledge particularly the coordination expertise demonstrated by SUSIO and to thank the many contributors to this project who performed formidable tasks with minimum remuneration. The FCCC feels that ESCAROSA I illustrates how research is indispensable in providing indications and conclusions to the planners and how they, in turn, can use the research information to recommend better management plans and controls to the policy-makers at all levels of government.

Bruce Johnson and Fred Barloga
FCCC Staff

INTRODUCTION

As a direct consequence of the rapid urbanization and industrial development of the coastal zone of Florida during the last two decades, increased use has been made of the rivers, bays, and inner-shelf areas as disposal regions for liquid and solid wastes. This usage for disposal purposes is frequently incompatible with continued harvesting of both finfish and shell-fish, and with recreational activities in the same waters. Because these competing usages will more likely increase than decrease in the years ahead, it becomes progressively important that "basic" or "background" data be accumulated that will allow adequate legislative measures to be enacted before the coastal zone is altered beyond recovery.

An aroused public understanding of man's past degradation of the environment of this region, the probable further land development, and potential offshore oil exploration and production has led to increasing pressure for the creation at the state and federal levels for some type or form of coastal management plan and an administrative system to implement this plan. It is surprising how frequently the assumption is made that the necessary "basic" data required for such a plan are in existence, processed, analyzed, and ready in the proper format for use by the appropriate agency. In the ESCAROSA area, as in most places, this is simply not the case.

As stated in the preface, a preliminary survey of existing sources of information (federal, state, university, and private) on all aspects of the biophysical environment of ESCAROSA established the fact that practically nothing was known of the oceanology of the territorial seas, and that there were considerable gaps in the existing knowledge of marine ecology in both the estuaries and in the Florida territorial seas.

The primary purpose of ESCAROSA I was to provide essential data to eliminate, insofar as possible, this lack of baseline information for the portion of the Florida territorial sea between 86.8° to 88.0° West longitude and extending from Mean High Water (MHW) to nine nautical miles offshore.

The initial funding of $15,000 required that the extremely complex, interdisciplinary processes occurring within the region must be examined to locate the most critical information "gaps". It was realized that this level of funding could not produce the amount of data in each discipline and area which all concerned would like to see, or which would be needed in the future. It is hoped that the selected study area for which data have been collected has provided sufficient information for more precise definition of environmental quality problems relative to this unique region and, hopefully, will suggest further studies that will allow definitive statements leading to the resolution of a number of the presently unresolved problems relative to these interests.

In an attempt to determine the extent of these information gaps, an examination of the existing data banks and published and unpublished reports of the area was made. This

determined the amount of historical data available for the physical parameters of water transportation, water mass identification, temperature, and salinity. These particular parameters were selected because the importance of the interrelationship of water movement to the scientific studies in all disciplines in oceanology has led to the more or less uniform measurement of these items. In short, if any data are available in a region, they should occur in these parameters. Physical data, therefore, are a good indication of the status of background information in other parameters.

Since the primary emphasis of the study was to be on the territorial seas of Florida, an examination of the National Oceanographic Data Center (NODC) data files and all unpublished data demonstrated that not enough information was available in the Florida territorial seas to determine the seasonal structure of the region, much less describe any monthly or yearly variation. The distribution of the historical stations is so gross around the entrance to the ESCAROSA and Perdido Bay systems as to prevent any description of the water action relative to the rivers, bays, and shelf and open Gulf of Mexico waters.

The extent of this data gap is graphically illustrated in Figures 1 and 2. These figures represent the actual number of computerized physical oceanographic stations and Mechanical Bathythermograph (MBT) lowerings available at NODC through 1970. The number of observations are recorded as numbers in each Marsden Square. A summary of the numbers in each figure, therefore, provides the total number of observations within the Continental Shelf and open Gulf of Mexico waters. These numbers do not include data available within

the estuaries and rivers which are stored in STORAT (a different data bank, concerned with estuarine and river regimes). The separation in data between STORAT and NODC is a line drawn across the entrance to a bay or estuarine system.

The solid rectangles on Figure 1 indicate the problems faced by anyone attempting to produce either a seasonal or monthly summary of physical environmental conditions. The rectangles represent NODC's attempt to produce a historical data base in atlas form for the oceanographic variables of temperature, salinity, oxygen, and phosphate. As such, they represent a concentration of enough data to allow summations of these variables. It can readily be seen that they do not represent areas of oceanographic similarity or lend themselves to the production of summations of detailed individual areas.

In view of the paucity of information available even for the "classic" parameters, how can one hope to evaluate such exotic problems as trace metals and pesticides and their effects on the biomass and sediments within this system? Even such basic questions as the dispersal or concentration of contaminants in these systems cannot be evaluated, or if they are dispersed, to where they would be transported.

It was, therefore, agreed that one sampling program must involve the collection of the classic physical data of temperature, salinity, and oxygen with particular attention to the study of possible "plume" structures off the mouths of Escambia and Perdido Bays. To insure the maximum efficacy of these data, collection was scheduled in conjunction with the August, 1971, EGMEX/WFCSP projects, as these operations would allow the ESCAROSA data to be related to a detailed study of the existing circulation in the Eastern Gulf of Mexico.

A cooperative agreement with the Florida Department of Pollution Control provided for the collection of weekly data from the mouths of Escambia and Perdido Rivers through the estuaries to the entrances of the bays, from August 17 through September 13, 1971. The data from these surveys with the ESCAROSA and the WFCSP/EGMEX stations has resulted in continuity of data from the rivers to the open Gulf waters. This continuity of data was another of the objectives of the ESCAROSA program and was important to, and directly connected with, a study of the distribution of trace elements and pesticides.

A second sampling program addressed itself to the environmental problems associated with trace elements and pesticides. The increase in these chemical compounds caused by the rapid urbanization, agricultural, and industrial development of a relatively undeveloped natural area, has created a complex type of contemporary management problem. This problem has been influenced by a complete lack of adequate "basic" data on the natural (normal?) level of these particular effluents in the territorial seas.

The collection of this information was, therefore, considered mandatory for ESCAROSA I, not only because of its basic need but also because of the existence of similary broad geographical programs currently in progress on the Western Continental Shelf of Florida and the Eastern Gulf of Mexico (EGMEX I and II). The cost efficiency was increased because the same data collection system could be used for both the physical and chemical programs.

Because of the importance of the trace element and pesticide data, and the fact that influence of different sampling techniques could be eliminated between these and the EGMEX

data, it was deemed a fundamental necessity to provide a precise inter-calibration of selected analyses systems and techniques used within the region. This led to the last of the funded programs, which provided duplicate trace element and pesticide samples to be used to determine the conformity of analytical results. This would allow scientific investigators to use past and future data collected within the area as well as analyses by different systems and techniques.

These latter two programs attempted to collect, analyze, and interpret, with a high degree of accuracy, specific and characteristic trace metals and pesticides within the region most affected by the water action relative to Escambia and Perdido Bay systems. Their primary purpose was to document the levels of occurrence of these variables.

Although the initial FCCC funding of $15,000 supported only the above-mentioned programs, this report contains considerable additional information. As ESCAROSA was discussed throughout the oceanographic community, a number of organizations, agencies, and scientific investigators agreed to participate in the overall ESCAROSA program. These contributions were in the form of money, equipment, personnel, analysis of samples, reduction of data, and last but not least, the publication of individual research papers.

SUSIO and the Florida Coastal Coordinating Council wish to express their appreciation and acknowledgement to the following organizations and individuals for their contributions to this report:

The National Science Foundation, under contract GA 29590, for the use of EGMEX data.

Amoco Petroleum Company; Gulf Oil Corporation; Humble Oil and Refinery Company; Mobil Oil Corporation; Phillips Petroleum Company; Shell Oil Company; Standard Oil Company; Sun Oil Company; Texaco, Inc.; and the Florida Petroleum Council for ship support of the R/V DAN BRAMAN in support of the "Comprehensive Long Term Study of the Nearshore and Estuaries of the Florida West Coast."

The National Oceanic and Atmospheric Administration's Atlantic Oceanographic and Meteorological Laboratory for the analysis of water samples for inorganic phosphate, nitrate, nitrite, and silicate. These data were made available to the ESCAROSA personnel and are included in this report. Moreover, the data will be included into AOML's study of the distribution and concentration of inorganic phosphate, nitrate, nitrite, and silicate and their relation to the water characteristics of the Loop Current in the Caribbean waters.

The National Oceanic and Atmospheric Administration's Southeast Fisheries Center for computer service for processing the physical oceanographic stations.

Dr. H. K. Brooks of the University of Florida for the collection of sediment samples and bottom pictures aboard the R/V DAN BRAMAN. These pictures and samples will form a part of the Western Florida Continental Shelf Program sediment and bottom photography study.

The National Oceanic and Atmospheric Administration's National Oceanographic Data Center for computer and programming services in the processing and combining of physical and chemical data from ESCAROSA. They also established a procedure, which transferred the ESCAROSA data from their data files to the Environmental Protection Agency's STORAT data center.

The Phillips Electronic Instrument Company for the analysis of duplicate trace element samples by their Phillips Application Laboratory as part of the inner calibration program.

The Environmental Protection Agency's Gulf Breeze Laboratory for the analysis of trace element samples as part of the inner comparison program.

The Houston Operations of the System Group of TRW, Inc. who use ESCAROSA data in a pilot study for a data management computerized system. They have issued a status report entitled "The ESCAROSA Bay Data Management Project."

The Gulf University Research Consortium Field Office at the Mississippi Test Facility for the use of the data in a data management and retrieval system. There is a separate report by this organization in regard to their data management system.

The New York Ocean Science Laboratory for the analysis of trace elements in the sediments. While these data appear within this report, it will also be used in a technical report by the New York Ocean Science Laboratory to compare trace element concentrations in the New York Bight and ESCAROSA areas.

Appreciation is also expressed to the faculty members and graduate students of the following universities and agencies who participated as scientific personnel during the cruises: Florida Coastal Coordinating Council, Florida State University, Marine Science Institute of Alabama, University of Alabama, University of Florida, University of Houston, University of Miami, University of West Florida.

During the planning of the cruises, it was agreed that trace metals and sediment samples would be taken at each station. It was realized that the limitations of funds would prevent the complete analysis of all of the samples. After examination of the physical data, the Florida Coastal Coordinating Council issued an additional contract to complete the analysis of all water samples for trace elements and pesticides and to determine the sedimentology and clay fraction mineralogy of the samples taken by the Ekman dredges. Additional money was made available for this study when one of the participants in the inter-calibrations trace metal test was unable to complete his obligation for these analyses.

Preliminary results of the trace metal, pesticides, sediments, and clay fractions have been issued in three separate reports. These are:

Corcoran, E. F. A Study of the Distribution and Concentration of Trace Metals and Pesticides of the Florida Territorial Sea Off ESCAROSA: ESCAROSA I-71.

Griffin, G. M. Sources and Dispersal of Clay Minerals in the ESCAROSA Area of Northwest Florida As Related to the Movement of Particulate Pollutants.

Jones, J. I., R. Rohrich, J. L. Jones. ESCAROSA I, Sediment Analysis and Interpretation.

The purpose of this report is to combine these three separate preliminary papers along with the supplementary information supplied by non-funded agencies, universities, and organizations who participated in EGMEX, into one comprehensive document. To accomplish this purpose, editorial license has been applied to the reports and to the supplemental data by Dr. James I. Jones (FCCC) and Mr. Murice O. Rinkel (SUSIO).

OPERATION DESCRIPTIONS

Design of Survey

Figures 1 and 2 demonstrate the limited amount of background information in the national archive data files available for use in planning an oceanographic survey in the ESCAROSA area. Examination of both published and unpublished data confirmed that little was known of the structure of the physical characteristics of the territorial seas off Perdido and Escambia Bays. Lacking any significant background data in the area, it was therefore necessary to plan the operation based on research performed on the circulation system in the Eastern Gulf

of Mexico: primarily the current and physical structure of the waters of the outer continental shelf beyond the 50-fathom line off Panama City, as well as waters within Mobile Bay.

In the project area, the dominant controlling factor for shelf circulation patterns is the Eastern Gulf of Mexico Loop Current. This feature has been studied in detail by Texas A and M University, and in recent years, by a consortium of universities and government agencies under the project title of "Eastern Gulf of Mexico" (EGMEX). These studies indicate that the Loop Current progresses northward from the Yucatan Channel into the northeastern Gulf of Mexico where it becomes a major factor in the circulation in the Pensacola area during the months of May through September.

A graphic representation of the effects of this circulation feature is shown in Figure 3, from the May, 1970, EGMEX cruises. This figure shows the depth of the 22°C isotherm which has been used by some investigators to indicate the location of the Loop Current (see Leipper, 1970). As shown by this figure and by Figure 4, this current approaches the edge of the continental shelf where it becomes a dominant factor in the shelf's circulation pattern. Gaul (1967) states that the current "forms vertically polarized vortices having characteristic diameters of 100 kilometers that migrate along the shoreward flank of the Loop Current." These eddies may be either cyclonic or anti-cyclonic and appear intermittently over the continental shelf between the DeSoto Canyon and off Cape San Blas. He feels that the circulation can be envisioned in terms of a two-layered system. This two-layered system is separated by a transition layer, which is bound above by the seasonal thermocline and

below by the salinity maximum. This transitional layer is compressed toward the shore and shortened during the warm months but virtually disappears over the shelf in the winter. The flow in the lower layer is more directly coupled to the main current system offshore than are the surface layer currents. Major storms, fronts, hurricanes, and tidal and inertia currents will introduce circulation features within the area, but Gaul (op cit.) feels that these are primarily confined to the surface layer and that the flow in the lower layer is more directly coupled to the main current system offshore than are the surface layer currents.

Figure 5 (Austin, 1971) shows the influence of the Loop Current on the water mass structure of the area. Two perturbations can be seen on the northern edge of the Loop Current. These will detach themselves from the Loop Transition Water and move inshore onto the shelf as eddies, influencing the Eastern Gulf of Mexico mixed water mass structure.

Knowledge of the importance of understanding and recording the structure of the Loop Current in any survey within the territorial waters off Perdido and Escambia Bays resulted in the coordination of the ESCAROSA project with the EGMEX IV Loop Current study conducted in August of 1971. ESCAROSA was deliberately scheduled two weeks after EGMEX IV to enable the planners to study the Loop Current structure and make any necessary changes in the proposed transect or station sampling locations. This two-week delay was required for the EGMEX participants to reduce the temperature and salinity data for use by the ESCAROSA participants. A planning session was held to examine the EGMEX data two days before the initiation of the ESCAROSA experiment.

Work by Salsman (1962) and Boston (1964) from an offshore platform in 60 feet of water within a restricted 80 square mile area, in water depths from 60 to 100 feet off Panama City, Florida, indicated a vertical temperature variation of a periodic nature with isothermal structures in late summer through the entire winter, but with a well-defined thermocline in the spring. This thermocline persisted from March through July and exhibited a periodic temperature variation in phase with the local diurnal tides. Similarly, the temperature, salinity, and current data taken in June of 1962 showed that temperature variations in the depth of the top, center, and bottom of the thermocline were closely related to the amplitude and phase of the surface tides. Further, these relationships varied with the depth and distance from shore. Tolbert and Austin (1959), while examining the coastal currents off Panama City, compiled data from various local surveys and found that the surface current usually flowed parallel to the shore and to the southeast, nearly as often as to the northwest. Tolbert and Salsman (1964), during a 72-hour survey in June, measured a tidal excursion with a 24.8 hour period and a non-tidal, onshore component of surface current measuring 7 cm/sec. The tidal excursion covered about four miles.

Tolbert and Salsman (1964) conducted a 28-month drift-bottle study from this offshore platform. An analysis of the returns indicates that the local net transport is influenced by both tidal currents and wind stress, with the wind currents having the major effect. The percentage of recoveries agree with the frequency of direction of the wind flow at Panama City. While the primary mechanism of the surface water transport in the vicinity of Panama

City is the wind, the geographical area of recovery indicates that once the drift bottle was transported away from the platform other currents dominated the movement characteristics. Except for August, there were recoveries throughout each year which indicated a major westerly, southerly or southeasterly direction component. In August, there was no southerly flow. In short, while the local transport can be predicted from the wind currents, long-term transport is dependent on an understanding of the complex shelf circulation and Loop Current interrelationship.

Figure 6 shows the prevailing surface currents by season, based on all the available surface current data in the national files. An examination of these figures indicates that the results reported in the drift-bottle work does not seem to be in agreement with the existing theories of two or more semi-permanent eddy systems within the area.

Since the survey was designed to study the effects of the discharge of effluents from Perdido and Escambia Bays into the territorial waters, a search was made of the historical data in an attempt to determine the flushing rates of the bays. One study of these rates appeared as a report in the Second Session of the Conference in the Matter of Pollution of the Interstate Waters of Escambia Bay River Basin (Alabama-Florida) and the Intrastate Portions of the Escambia Basin and Bay Within the State of Florida (1971), entitled "Circulation and Benthic Characterization Studies, Escambia Bay, Florida", by the Environmental Protection Agency. It states that the tides within the Pensacola Bay system are diurnal with a 1.1 foot tidal range and with a displacement time for Escambia

Bay (as a whole) of 18 days and for only Upper Escambia Bay of 3.2 days. This compares with Austin's (1954) report which gives a flushing rate of 45 to 54 days for Mobile Bay. A second study of Escambia Bay (Flood and Associates, 1973) indicates a flushing time on the order of 54 days. These data indicated that if the study on the territorial waters was to consider the effects of the effluent from the bays, sampling within the bays themselves would have to be conducted in advance of operations on the shelf.

A number of planning sessions for ESCAROSA were held to review background information and to establish the assumptions, guidelines and goals for the project. Individuals from the following organizations attended these meetings: Florida Coastal Coordinating Council, State University System Institute of Oceanography, Florida Department of Pollution Control, University of Florida, University of West Florida, Florida State University, University of Miami, Florida Department of Natural Resources, Gulf Universities Research Consortium, National Aeronautics and Space Administration, T.R.W. Inc., and the Environmental Protection Agency.

The location of the sections and stations decided upon are shown in Figure 7. The assumptions and guidelines used in the location and positioning of the sections and stations shown in Figure 7 were the following:

1. The primary region of data collection would be concentrated from mean high water (MHW) to nine nautical miles offshore and from $86^{o}48'$ to $80^{o}00'$ West longitude. These boundaries represent the approximate judicial limitations

placed on the planning and enforcing groups in the state of Florida.

2. The maximum effect on the territorial seas off ESCAROSA from land run-off would occur in a plume-type discharge from the entrance of Pensacola and Perdido Bays. For this reason, the sections were planned with a closer longitudinal interval around these potential dispersion areas. The sections were established in a north-south direction using longitude $96^{o}17.6'W$ as the starting section (Section 1).
3. That by running the vessels on a north-south section probable plume distribution with a 6-hour time period could be obtained. This is the length of time necessary to run a section and return to the north starting point of the next section.
4. The dispersion of the discharge from these estuaries or from any possible spillage within the territorial limits of the jurisdiction of the state of Florida would be influenced by:
   A. Onshore-offshore tidal oscillations
   B. An eastward or westward along-shore current
5. The major effect on the distribution and dispersion would result from the tidal oscillation. For this reason, the R/V TURSIOPS occupied a time series section off the main entrance of Pensacola Bay on a 6-hour interval for 48 hours. As did the other ships, she ran this section in a north to south direction only. All vessels

coordinated their sections with the R/V TURSIOPS 6-hour sampling interval. The messenger time for each hydrographic cast at each station was coordinated by a set schedule.

6. That the air and water pollution control scientists would take samples on a weekly schedule beginning on August 18 and continuing through September 14, with 12 stations in Pensacola and Escambia Bays and 6 stations in Perdido Bay.
7. The first offshore station in each section would be one-half mile from the shoreline, using radar navigation. Thereafter, stations would be at two-mile intervals, with the last station nine miles offshore. When possible, all sections would start in reference to a predominant structure, which could be seen on radar or visually.
8. All planning and figures would be reduced to the baseline charts of the Coast and Geodetic Survey numbers 1265 and 1266.

Data Collection Systems

The data requirements necessitated the collection of physical, chemical, meteorlogical, and geological samples and observations. They consisted of the collection of water and sediment samples, and the recording of sea temperature and meteorological data of wind direction and speed, sea and weather state, and tidal conditions. The systems used were:

Oceanographic Station Casts

At each station, a cast was made to collect water samples for the determination

of salinity, dissolved oxygen, trace metals, pesticides and for the measurement of inorganic phosphorus-phosphate, nitrate, nitrite, and silicate. These samples were collected by standard Oceanographic Station Cast techniques with the following specialized conditions:

At each station, the hydro weight was lowered to the bottom to obtain a bottom depth sounding. The depth of the bottom bottle of the cast was adjusted to within one-half meter of this value.

At each station, a MBT was taken before the oceanographic cast to determine the vertical temperature profile. This profile was used to adjust the bottle to the depth of the thermocline.

On stations located within one-half to two and one-half miles offshore, a bottle was located at the surface and at the bottom. On the outer three stations of each section, an additional bottle was located at the thermocline depth.

Each cast consisted of from two to three 5-liter Niskin water sample bottles. On the R/V BELLOWS and the R/V DAN BRAMAN, all bottles were equipped with two reversing thermometers. On the R/V TURSIOPS, because of a shortage of thermometer-holder equipped 5-liter bottles, an additional 1.7-liter Niskin bottle equipped with two reversing thermometers was added to the casts on Stations 03, 04 and 05. These casts, therefore, had thermometer-equipped 5-liter bottles at the surface and bottom and a 1.7-liter bottle at the thermocline.

The soaking time for each cast was ten minutes. All cast data were recorded on NMF-TABL Hydrographic Station Logs, Form 2-TABL-33, with station information on Master Station Record Form T-TABL-30.

Prior to the departure of the vessels, the scientific party was instructed on the proper sampling methods to prevent contamination of trace element samples. All 5-liter bottles were washed with a high grade detergent, rinsed with fresh water, Acetone, and finally, with a dilute solution of HCl acid. The cable aboard the R/V BELLOWS and R/V DAN BRAMAN was replaced with new wire before the departure of the vessels.

Water samples were drawn from each bottle on the cast according to specific instructions and in the following order:

a. Salinities were drawn first, into two French-type bottles equipped with

cone polypropolene caps, according to EGMEX '70 INSTRUCTIONS FOR SAMPLING OXYGEN AND SALINITY.

b. Oxygen samples were drawn according to EGMEX '70 INSTRUCTIONS FOR SAMPLING OXYGEN AND SALINITY into 150 ml brown oxygen bottles on board the R/V TURSIOPS where no samples were drawn from the 1.7-liter bottle on Section 1, 2, 3, 4 and Station 03 on Section 5; and on the R/V DAN BRAMAN except from the bottom on Station 65. On the R/V BELLOWS, the oxygen samples were drawn into 500 ml brown bottles. All samples were treated aboard with $MnSO_4$ and KOH-KI. The samples were then either stored below decks or in the dry laboratory, in light-tight cases. These cases were immediately returned to Florida State University following the completion of the cruises on September 16, where they were acidified and titrated by September 18, 1971. The longest any sample was held before analysis was 96 hours.

c. Nutrients.

A minimum of 250 ml of water were drawn into Sears No. 11-7647 one-pint freezer food bags. Each bag was placed into a second similar bag and the open mouths simultaneously tied shut, on the R/V BELLOWS and R/V DAN BRAMAN. On the R/V TURSIOPS, "Nasco" Whirl-Pak Bags were used. All samples were immediately frozen and remained frozen until analysis. Samples were drawn according to EGMEX INSTRUCTIONS FOR IPO_4, SiO_3, NO_2 and NO_3, based on information provided by Mr. George Berberian, NOAA/AOML.

Selected water samples were drawn for:

a. Trace Metals

R/V BELLOWS

1. Two 1-liter samples from all bottles on Section 14, 15 and Station 42 on Section 16.

2. One 1-liter sample from all bottles on Station 43, 46, 47, 51, 56 and 57.

3. One 1-liter sample was drawn from the surface and bottom bottles on Station 44, 45, 48, 49, 50, 53, 54, 58 and 59.

4. One 1-liter sample from the bottom bottle on Station 41 and two 1-liter samples from the surface bottle.

R/V DAN BRAMAN
1. Two 1-liter samples at all depths except for the 25-meter bottle on Station 020 and all bottles on Station 065.

R/V TURSIOPS
1. Two 1-liter samples from all 5-liter bottles on Section 1.

2. One 1-liter sample from all 5-liter bottles on Section 4 and on Station 005 on Section 8.

3. One 1-liter sample was drawn from the surface and bottom bottles on Sections 2, 3, 5, 6, 7 and on Stations 001, 002, 003 and 004 on Section 8.

These samples were drawn into 1-liter polypropylene bottles containing hydrochloric acid in the amount to bring the samples to pH2, according to EGMEX '70 INSTRUCTIONS FOR SAMPLING TRACE METALS AS MODIFIED FOR ESCAROSA I.

b. Pesticides.

Pesticide samples were drawn into 1-liter glass bottles with Teflon-lined caps. The bottles had been cleaned and were not rinsed.

Samples were drawn from:

R/V BELLOWS
1. From all bottles on Stations 031, 032, 037, 041, 042, 046, 047, 051, 056 and 057.

2. From surface and bottom bottles on Stations 033, 034, 035, 038, 039, 040, 043, 044, 045, 048, 049, 050, 053, 054, 055, 058, 059 and 060.

R/V DAN BRAMAN
From all surface and bottom bottles on all casts.

R/V TURSIOPS
1. From surface and bottom bottles on Sections 1 (except bottom bottle on Station 005), 4 and 8.

2. From surface and bottom bottles on Station 001, on Sections 2, 3, 5, 6 and 7.

STD

Aboard the R/V TURSIOPS, on all Stations on Section 1, and on Stations 003, 004 and 005, and on all the remaining Sections (2-8) a 1000-meter Model 9060 Bissett-Berman STD Unit, Serial No. 5572 was lowered to the bottom. The lowering rate was 20 meters per minute. Calibration data consist of information from the BT taken before the lowering and from Ocean Station Casts taken after the lowering. Lowerings were according to EGMEX '70 INSTRUCTIONS FOR SAMPLING MODEL 9060 BISSETT-BERMAN STD UNIT.

Ekman Dredges

All vessels were equipped with Ekman dredges. These dredges were used to take a bottom sediment sample at each station. The R/V TURSIOPS did not take samples on Sections 2, 3, 4, 5, 6, 7 and 8 (except on Section 3, Station 1 where an additional dredge sample was taken in the center of Caucus Channel). From these samples, a 1-liter sediment sample was placed in a glass container with a Teflon-lined cap and stored at low temperature.

Drift Bottles

At selected stations, 12 TABL-Miller-type drift bottles were released. These releases were part of a NOAA-Southeast Fisheries Center drift-bottle study run in connection with the Western Florida Continental Shelf Program and EGMEX. Bottles were released as follows:

1. R/V BELLOWS
   On Stations 031, 033, 034, 035, 036, 038, 040, 041, 043, 044, 045, 046, 048, 050, 051, 053, 054, 055, 056, 058, 059 and 060.

2. R/V DAN BRAMAN
   On Stations 007, 009, 012, 014, 018, 019, 020, 022, 023, 024, 025, 027, 029, 062, 063, 064 and 065.

These releases do not appear in this report; they will, however, appear in a report by the Southeast Fisheries Center to be released as part of their Western Florida Continental Shelf Program.

Camera-Grab

Aboard the R/V DAN BRAMAN, a camera snapper/grab device was lowered at each station as part of the University of Florida's bottom stress factor study in the Western Florida Continental Shelf Program. A total of 20 bottom pictures were taken with 30 grab samples. These data do not appear within this report, and will be the subject of a special report by the University of Florida.

Meteorological Observations

At each station, observations were made of wind speed and direction, wave height and period, and weather. These observations were recorded on the Master Station Records, Form T-TABL-30, according to the codes in the National Oceanographic Data Center publication M-2. Wind direction was recorded according to Table 8, which is a combination of WMO Code 0885 and 0887 to the nearest tenth; wind speed according to Table 14 to the nearest whole knot; wave height according to Table 10 as a code; wave period according to Table 11 as a code; and weather according to Table 21 as a code. These observations may be requested from SUSIO or the Florida Coastal Coordinating Council. These data are summarized and appear as Appendix I.

Navigation

All navigation was performed by the use of radar and LORAN fixes. The LORAN fixes were recorded on SUSIO's Bridge Log Sheets. A copy of these log sheets is available from SUSIO or the Florida Coastal Coordinating Council. The positions have been recorded in degrees and minutes according to the National Oceanographic Data Center's publication M-2 to the nearest tenth of a minute.

Logs

The original raw data records for the cruises were recorded on the following log sheets:

1. Bridge Record Log - SUSIO (LORAN and radar fixes)

2. Master Station Record, Form T-TABL-30

3. Hydrographic Station Record, Form 2-TABL-31

4. Salinity determination by inductively coupled salinometer (USNOO - Oceanographic Log Sheet - DDD)

5. NAMDI (inventory forms)

6. Deck Log

7. Scientific Log

8. Track Charts

These record sheets have been submitted to the Florida Coastal Coordinating Council as part of the documentation requirement for this study. Copies of them may be obtained from either the Florida Coastal Coordinating Council or SUSIO upon request.

ANALYTIC METHODS

Temperature

The protected reversing thermometer temperatures were corrected using thermometer calibration data run on February 2, 1971. The values were corrected using the University of Miami Reversing Thermometer Computer Program on Southeast Fisheries Center forms, and through the courtesy of that organization. If the readings did not agree with $\pm$ 0.02°C, both values were recorded for plotting on the station curves. The temperature data are considered to have an absolute accuracry of $\pm$ 0.02°C.

Salinity

Two salinity samples from each bottle were returned to Florida State University where they were analyzed using a Bissett-Berman Laboratory Salinometer, Model No. 6230. On arrival at Florida State University, the samples were stored in an air-conditioned

laboratory, and were analyzed during the period September 21 to 23, 1971. Standardization was by Copenhagen water at the start and finish of 20-sample runs. If the salinity values agreed within ± 0.03 parts per thousand (°/oo), they were averaged. If not, both values were recorded. The results are believed to have an absolute accuracy of ± 0.03 °/oo.

Oxygen

The oxygen content of the samples was determined by the procedures outlined in Strickland and Parsons (1968). The reagents $MnSO_4$ and KOH-KI were added to the samples aboard the vessels as described in Data Collection Systems above. The samples were acidified and titrated, using a modified Winkler method. All samples were titrated by September 18, 1971. They are considered to have the accuracy normal to this technique. Oxygen saturation values were computed using Fox (1909). These values are tabulated and appear as Appendix II.

Mechanical Bathythermograph (MBT)

MBT slides were adjusted to the surface reversing thermometer temperature. The slides were then read at every five meters, inflection point, and half and whole degrees of temperature. These values were recorded on National Oceanographic Data Sheet Records, and submitted to that organization.

Salinity-Temperature-Depth (STD) Recorder Lowerings

STD lowerings were used to check the Oceanographic Station Casts and in the construction of station curves. The data were not reduced or submitted to any national depository. The traces, however, are available from either SUSIO or the Florida Coastal Coordinating Council.

Station Curves

Station curves were constructed to the Western Florida Continental Shelf Program and EGMEX scales for each station for temperature, salinity, sigma t, T-S and oxygen. The temperature, salinity, and sigma t were plotted against depth; the oxygen against temperature. These curves were used to determine any questionable temperature or salinity observations. Data were digitized onto NODC Oceanographic Station Cast Forms for observed value of temperature, salinity and oxygen. In addition, values were recorded for temperature and salinity at each whole and half degree in temperature and 0.02 parts per thousand in salinity. These data were submitted to NODC as a requirement of the contract. Interpolated data is available from SUSIO.

IPO_4

Analyses were conducted on a Technicon Autoanalyzer, following the procedures of Murphy and Riley (1962). These data were developed as part of the NOAA/AOML study of IPO_4 in the Caribbean and Gulf of Mexico, and will appear as a separate report by that organization.

NO_2/NO_3

Analysis was completed using a Technicon Autoanalyzer according to the procedures described in Brewer and Riley (1965). These data were run as part of the NOAA/AOML study of NO_2/NO_3 in the Caribbean and Gulf of Mexico, and will appear as a separate report by that organization.

SiO_3

Analyses was completed using a Technicon Autoanalyzer as described by Brewer and Riley (1966). These data were taken as part of a study of the SiO_3 in the Caribbean and Gulf of Mexico by NOAA/AOML, and will appear as a separate report by that organization.

Trace Metals - Water Samples

The water samples for trace metal analysis were drawn into and stored in polypropylene bottles containing sufficient hydrochloric acid to bring the pH below 2. In the laboratory, a 150 ml sample was measured into an Erlenmeyer flask, potassium persulfate added, and autoclaved for one hour. After cooling, the pH was adjusted with ammonium hydroxide to just above 8, and the trace minerals present were collected on a Chelex 100 Column, according to the procedures of Riley and Taylor (1968).

The trace metals were then eluted with 4N nitric acid and 4N hydrochloric acid into silica flasks. After pH adjustment, five ml of 2% ammonium phyyolidine dithiocarbamate (APDC) solution was added to the acid eluate, and it was extracted with two ml of methyl isobuthl ketone (MIBK). Two additions of APDC and two extractions with MIBK were made. The combined Ketone extracts were collected in a silica flask and evaporated to dryness. Two ml of concentrated nitric acid were added to each flask, and the samples were again dried over low heat. The residues were dissolved in 10 ml of 4N nitric acid and the analyses performed on a Perkin-Elmer Atomic Absorption Spectrophotometer. This procedure is similar to that described by Brewer, et al, (1969). Flame was used for all analyses except lead

and cadmium. The heated graphite furnace was used for the latter metals.

Five 1-liter samples of seawater were concentrated to a heavy brine on a hot plate, then frozen with liquid nitrogen and freeze-dried to a dry salt. This salt residue was sealed in glass and sent to Philips Electronics for analyses by X-ray fluorescence techniques for intercomparison purposes.

The data presented in the following section were contoured at intervals no less than twice the mean deviation, the deviation being derived from multiple sets of duplicate analyses.

Trace Metals - Sediments

Prior to analysis, all sediment samples were dried at 103°C for 24 hours. Ten-gram samples were then weighed into individual flasks and digested at low heat in a mixture of nitric-sulfuric-perchloric acid. An aliquot of the resultant solution was then reacted with Sn^{2+} and hydroxylamine to reduce the mercury to Hg^{o}. The mercury vapors were then carried through a dessicant to the absorption cell which had previously been positioned in the light path of a hollow cathode mercury lamp. The resultant attenuation of the beam of light (253.7 nanometer line) is a function of the quantity of mercury present in the vapor.

The remainder of the above sample was used for the determination of the other metals by atomic absorption spectrophotometry.

The sample size available for analysis did not permit replicate analyses to be conducted on these samples. The intervals chosen for contouring were selected subjectively to provide the maximum visibility for the variables investigated. No assumptions should be made, or

are intended, as to the relative importance of the absolute values from the standpoint of pollution evaluation.

Pesticides - Water Samples

Water was drawn from the sampler into 1-liter glass bottles fitted with Teflon-lined screw caps. Upon return to the laboratory, a 420 ml aliquot was extracted with 42 ml of 4:1 hexane-diethyl ether. This extract was twice dried over anhydrous sodium sulfate and concentrated to five ml in a Kuderna-Danish evaporative concentrator. The analyses were made by gas chromotography using a Beckman GC-5 gas-liquid gas chromotograph equipped with a helium arc (plasma) electron capture detector. At least two column systems were used for the separation and identification of the chlorinated hydrocarbon pesitcides. A one-quarter inch by six foot glass column packed with 1.5% OV-17/1.95% QF-1 on 80-90 mesh Gas Chrom Q, and one-quarter inch by six foot glass column packed with 5% QF-1 on 89-90 mesh Gas Chrom Q were used.

Pesticides - Sediments

Sediment samples were placed in glass containers with Teflon-lined caps and stored at low temperature until extraction. A 50-gram sample of sediment was extracted first with acetone using a Soxhlet, and then with hexane. The combined acetone-hexane extract was washed with a saturated sodium chloride solution several times. The aqueous washings were discarded and the hexane extract was dried over anhydrous sodium sulfate and concentrated in a Kuderna-Danish evaporative concentrator and then further concentrated to

300 microliters with the aid of a Kontes micro-concentration apparatus.

The 300 microliter concentrate was fractioned on a Florosil column before analyses by gas chromotography. This was done in the following manner: The 0.3 ml of extract was transferred to the top of the Florosil column (containing 2.0 grams of 60-100 mesh Florosil in a Size "B" Chromoflex Column) and eluted with 12 ml of hexane followed by 12 ml of 1% methanol in hexane. This fraction contained the heptachlor aldrin, pp'DDE, op'DDT and pp'DDT when present. A second fraction was collected by eluting the column with an additional 12 ml aliquot of 1% methanol in hexane. This fraction contained dieldrin, heptachlor exposide, endrin, B-BHC, lindane and pp'DDT when present. The volumes on these fractions were adjusted and analyses carried out by gas chromotography.

In all determinations, nanograde solvents purchased from Burdick and Jackson Laboratories were used. Complete reagent blanks as well as standards were run with each set of samples. An aldrin "spike" was added to the samples to serve as a recovery check as well as a marker for relative retention times. Clean-up procedures were used on all sediment samples and on water extracts heavily contaminated by PCB's. Identification of the chlorinated hydrocarbon pesticides was made through relative retention times on at least two column systems, compared with standards obtained from the Pesticide Repository USPHS, Perrine, Florida. Concentration was calculated primarily from peak heights. In general, procedures, methods and cautions from the Manual of Analytical Methods, prepared by the Primate Research Laboratory, Environmental Protection Agency, Perrine, Florida were

followed. Aliquots of water samples of selected stations were sent to the EPS, Office of Research and Monitoring, Gulf Breeze Laboratory, and to the State Air and Water Pollution Control Laboratory for intercomparison of analytical results.

The pesticide data were contoured at intervals no less than twice the mean deviation (the latter being derived from multiple sets of duplicate analyses).

Sediments and Clay Mineralogy

All sediment samples were collected by an Ekman dredge. This type of sample may be used only for selected, gross characterization of aspects of sedimentary parameters, and is not adequate for precise determination of many sediment characteristics which would routinely be measured in a detailed sediment study. They are sufficiently accurate, however, to be utilized for the analyses presented in this report.

Samples for analyses of clay mineralogy, grain size, and other sedimentological parameters were taken from the dredge sample and placed in a freezer bag. No special preservation techniques were utilized for these samples.

Recognizing the inherent limitations of the available samples for sediment characterization, only the following sedimentary variables were measured: size frequency distribution, with moment measure of phi mean; standard deviation, skewness and kurtosis; per cent organic material, by combustion; per cent carbonate material, by digestion; and per cent fine material, by wet sieving to remove and measure that portion of the sample finer than 62 microns. The techniques utilized are those described by Folk (1968), which

are standard sediment analysis methods. The size frequency distribution data and related statistical parameters are listed in Appendix III. The phi mean sediment size, per cent fine material, per cent carbonate and per cent organic parameters for the study area are illustrated in Figures 179 through 182. All sediment analyses were performed by Ms. R. Rohrich and Ms. Judith Jones in the geological oceanographic laboratory at Florida State University. The computer program which provided the sediment moment measures was run by Ms. Rohrich through the assistance and cooperation of the computer laboratory of the University of West Florida.

There are approximately six major species and numerous sub-species of clay minerals. They are distinguished by different crystal structures, differing reactions with complexing reagents, and differing X-ray diffraction, combined with complexing to produce specific changes in lattice structure. In the eastern Gulf of Mexico region, the principal clay mineral species are kaolinite, montmorillonite, and vermiculite (Griffin, 1962). Minor quantities of illite, chlorite, and mixed-layer types also occur. Associated with the clay minerals are lesser amounts of quartz, gibbsite, goethite, and calcite. Chemical formulas for the major minerals and accessories of the ESCAROSA area are listed in Table I. Methods used in this study to distinguish the various species are given in Griffin (1962), and additional procedures for interpreting the X-ray diffraction data are described in Griffin (1971). A thorough treatment of clay mineral structures, reactions and identification methods is provided by Brown (1961). The analysis and interpretation of all clay

mineral characteristics and information reported in this investigation are the work of Dr. George Griffin, University of Florida.

TABLE I

Chemical composition of clay and accessory minerals in the 2 micron fraction of the ESCAROSA area.

A. Major clay minerals

Kaolinite $Al_4[Si_4O_{10}](OH)_8$

Montmorillonite $(\frac{1}{2}Ca,Na)_{0.7}(Al,Mg,Fe^{+2})_4(Si,Al)_8O_{20}(OH)_4nH_2O$

Vermiculite $(Mg, Ca)_{0.7}(Mg, Fe^{+3},Al)_{6.0}[(Al, Si)_{8.0}O_{20}](OH)_4 \cdot 8H_2O$

Illite $K_{1-1.5}Al_4[Si_{7-6.5}Al_{1-1.5}O_{20}](OH)_4$

B. Accessory minerals

Quartz SiO_2

Calcite $Ca\,CO_3$

Gibbsite $Al\,(OH)_3$

Goethite $\alpha FeO \cdot OH$

Figure 8 shows the location and numbers of the Ekman dredge samples. The notation "NS" stands for no sample. This does not mean that a lowering was not made; only that because of the tidal conditions and the operational characteristics of the dredge, it

was impossible to procure a sample. Rather than break the continuity of the oceanographic station sampling program among the three vessels, instructions were issued that if the grab malfunctioned more than twice, the vessel was to depart for the next station. The Ekman dredge did not prove satisfactory for this type of sampling.

DISCUSSION

Physical

A. Loop Current

A cooperative investigation to study the Loop Current phenomenon in the Eastern Gulf of Mexico was conducted between the periods of July 25 and September 2, 1971, as EGMEX IV. Table II shows the vessels participating in this operation and the total number of samples or observations collected in regard to physical, physico-chemical, biological and current measurements.

While all of the information from these vessels is pertinent to the ESCAROSA study, those observations taken aboard the R/V DAN BRAMAN Cruise 272-7120, the R/V TURSIOPS Cruise SUS-7124, and the R/V OREGON II Cruise 0-7129, which were part of the Western Florida Continental Shelf Program in August of 1971, were used in the planning of the ESCAROSA operation.

It is possible to locate and determine the configuration of the Loop Current by the temperature distribution. During some times of the year, it can be located by measuring

TABLE II

EGMEX IV

Summary of Data Collected

Vessel & Cruise No.	Physical STD	Sfc.T.	BT	XBT	Physical-Chemical Hydro	Optical	Biology Bongo	O/C	ICITA	Neuston	Trawls	Currents Drogues	D.B.	Number of: Days	Stations
DAN BRAMAN SUS-7118	0	0	0	0	0	0	0	0	0	0	51	0	0	7	38
DAN BRAMAN SUS-7120	7	100	93	0	100	0	99	0	46	0	0	0	(100) 1200	15	100
TURSIOPS SUS-7121	0	81	63	20	81	0	51	0	4	29	0	0	(81) 972	18	81
BELLOWS SUS-7122A	12	12	0	0	9	9	5	7	0	0	0	0	(12) 144	8	13
BELLOWS SUS-7122B	6	28	0	19	4	0	0	6	0	0	0	0	0	6	18
DAN BRAMAN SUS-7124	0	20	20	0	0	0	20	0	0	10	0	0	0	5	20
OREGON II 0-7129	4	112	0	111	44	0	98	20	0	63	0	0	(105) 1260	21	112
RESEARCHER OSS-03	80	cont.	264	403	35	0	0	0	0	0	0	4	(60) 720	51	403
DISCOVERER	Because of weather, no samples in EGMEX area. Sampling in Caribbean.														
TOTALS	109	353	440	553	273	9	175/273	33	50/50	102	51	4	S-358 B-4296	131	785

the surface sea temperature. Figure 9 is the surface sea temperatures in the Eastern Gulf of Mexico during May of 1970 (EGMEX I), as determined by ART overflights by the U. S. Coastguard, and shows a typical illustration of this phenomenon. Unfortunately, during the summer and fall months, solar heating prevents the use of surface sea temperatures as an indicator of the Loop Current. On shelf areas, even the subsurface temperature cannot be used as an indicator as illustrated in Figures 14, 15, 18 and 19.

There is, however, another distinct layer in the water structure of the Gulf of Mexico which can be used as an indicator of the Loop Current. This is a subsurface salinity maximum, which Wüst (1964) has traced from the Atlantic through the Caribbean and into the Yucatan Straits. This water mass (Subtropical Water) enters into the Gulf with a salinity that has a value larger than the characteristic salinity of any other water mass within the Gulf. It is generally considered to be in excess of 36.5 parts per thousand.

Figure 10 shows the configuration and location of the Subtropical Water on the Western Florida Continental Shelf during August, 1971. As this water moves through the Yucatan Straits into the Eastern Gulf of Mexico and exits through the Straits of Florida, its outer boundaries mix with other water bodies within the Gulf of Mexico. Austin (1971) had defined this mixing layer as "Loop Transition Waters with salinities ranging from 36.00 to 36.50 parts per thousand." This water is shown on Figure 10.

Examination of Figure 10 shows Subtropical Water within 38 miles of Choctawhatchee Bay, which is on the eastern edge of the territorial sea of the Florida ESCAROSA survey area.

Further, it shows that the Loop Transition Water, which is a mixture of Loop Current and Eastern Gulf waters, is within 12 miles of Pensacola.

By using salinity as an indicator of the current pattern, the Subtropical and Loop Transition Waters are shown to be flowing onto the shelf in a northeasterly direction, turning to the east at the latitude of Choctawhatchee Bay, and flowing southeasterly along the shelf until they exit into the Straits of Florida. Of particular interest is the documentation of water transport from the Pensacola area into the Tampa-Ft. Myers area.

It cannot be assumed that anticyclonic circulation is the normal pattern for the Loop Current in August. Figure 11, which is the depth of the 22°C isotherm from R/V ALAMINOS Cruise 66-A-11 in August, 1966, shows an entirely different pattern. Here the Loop Current can be seen breaking into two distinct eddy systems. A similar occurrence has been recorded in the data from EGMEX VI in May, 1972. The circulation may be either anticyclonic or cyclonic, as shown by the preceding discussion. It is difficult, therefore, to generalize about the Loop Current structure and its effect on shelf circulation. It is a phenomenon which not only varies from year to year, but season to season as well. Its influence on the distribution and location of trace metals and pesticides in the ESCAROSA area, therefore, becomes a matter of long-term study. Such studies are extremely expensive and are usually beyond the financial and personnel resources of a single state. It is important, therefore, that the state of Florida make every effort to continue its

participation in any form of major study within the Loop Current structure in the Eastern Gulf of Mexico.

B. Shelf Circulation

Little has been published on the circulation pattern of the West Florida Continental Shelf. What publications do exist are characteristically gross generalizations based mainly on pilot chart or drift-bottle data, and a limited number of drogue measurements (Figure 6). Because of the expenses of direct current measurements, studies in selected areas have used the distribution of either temperature or salinity to infer the circulation pattern. Such an approach has been used in the Western Florida Continental Shelf Program, which has completed a seasonal study with cruises in February, May, June, August and November. An atlas of the sigma t, temperature and salinity distribution is in preparation for these cruises and will be published in the near future.

The data collected on the Western Florida Continental Shelf in August for temperature and salinity are presented in Figures 12 thourgh 21 for the surface, bottom and at the standard depths of 10, 20, 30 and 40 meters. While the surface and bottom temperature, salinity and sigma t figures cover the entire Western Florida Continental Shelf area, temperature and salinity at standard depths are shown only between 29-30°North latitude and 82-88° West longitude.

Figures 22 through 26 are vertical sections for temperature and salinity between 28° North and the coastline of the Florida panhandle, along sections run at 87°45', 87°08' 86°34',

86°00' and 85°30' West. All of these sections and horizontal figures were done at the same scale of the U. S. Coast and Geodetic Survey Chart 1007, and are contoured to the intervals of the data standards set by EGMEX and the WFCS programs. The circles are either station locations on the horizontal charts or bottle depths on the vertical sections. Shading has been applied to the figures to emphasize selected distribution features. Except for Subtropical and Loop Transition water masses, the shading does not represent distinct water mass structures in the Gulf of Mexico.

Examination of the temperature and salinity data from this study indicates that within the 100-fathom line the continental shelf from Mobile to the Dry Tortugas area can be divided into four environmental areas which have similar features. One such area exists between Mobile Bay and a line drawn from Cape San Blas southward to 28°N (SUSIO, 1972). This physical division agrees remarkably well with similar geological and benthic faunal and plant regimes.

The surface horizontal fields of sigma t, temperature, and salinity (Figures 12, 14 and 16) demonstrate a complex eddy circulation pattern across the continental shelf in August. The complexity of these patterns is more pronounced in the Mobile-San Blas area. Here the sigma t values range from 17.85 to 23.25, the temperature from 28.82 to 30.26°C, and the salinity from 30.66 to 36.94 °/oo.

The small range of temperature, along with the simplicity of the eddy patterns, indicate that the temperatures of the different water masses are relatively uniform at the surface, preventing the use of surface temperature to determine the locations of the various water

masses. Several of the eddies, in fact, might be the result of diurnal heating. No currents have been inferred from this temperature field.

The salinity distribution, on the other hand, reveals a very complex eddy pattern. Subtropical and Loop Transition water can be identified entering from the south along 28° North latitude, while Mississippi estuary water is entering from the west and mixing with the Florida west coast estuary water as defined by Chew (1955).

The horizontal charts of sigma t, temperature, and salinity for the bottom water (Figures 13, 15 and 17) do not show a complex eddy pattern system. Rather, they show a flow pattern which seems to conform to the bottom topography. Bottom values in these charts are defined as measurements taken between two and five meters off the bottom.

In order to examine the details and depth of these eddy patterns in greater detail, Figures 18 through 21 were prepared from the WFCS data for the area north of 28° North latitude. As stated above, appropriate shading has been applied to emphasize selected distribution features.

The complex eddy distribution patterns of salinity and the relatively uniform temperature pattern recorded at the surface persist in the Mobile-Cape San Blas area through the 5-meter standard depth level. A transitional layer is present between this and the 15-meter level. Here the distribution patterns are changing into a flow structure aligned very closely to the bottom topography and similar to the distribution of the salinity core maximum (Figure 10). This pattern is graphically shown on the temperature field (Figure 19)

where Loop Current and Loop Transitional waters are entering the shelf from the southwest, turning to the east, and then to the southeast.

The 10 and 15-meter standard depth levels illustrate an interesting feature of the area: the subsurface flow of Mississippi estuarine water across the area from the west to the east in the vicinity of Cape St. George, where the water either terminates nearshore or turns to the southeast. It does not enter into the Big Bend area, which contains lower temperature water. This distribution pattern of lower temperatures in the Big Bend area has been noted in data from the WFCS program for other seasons, and appears to be a distinguishing feature of that area.

Figures 22 through 26 are vertical sections of temperature and salinity plotted against longitude between Mobile Bay and Cape San Blas. They demonstrate the vertical interfacing of the Loop Current, Loop Transition, Mississippi estuarine and Eastern Gulf Shelf waters. The salinity field at this time of year graphically demonstrates these interactions.

On the vertical sections, the doubled, heavy black lines represent the bottom configuration. The sections are shown to 200 meters only. If there were bottles below that depth which influenced the contouring, a "b" was placed above the station number. The station numbers are the master station designators for the WFCS program and do not refer to the hydro cast numbers. If the sampling did not occur within 10 meters of the bottom, the depth of the lowest bottle is indicated by double bars. In the temperature field, if XBT or MBT lowerings exceeded the depth of the bottom bottle, the temperature contouring is

based on the values from these observations corrected for calibration error by use of the oceanographic station data. On the salinity sections, where a salinity determination from the casts was lost, the contouring is represented by dashed lines.

The Loop Current and Loop Transitional waters can be seen entering onto the shelf and reaching their maximum penetration on Figure 24 at latitude 86°34' West. It is interesting to note that the Loop Current water (in excess of 36.5 parts per thousand) forms an enclosed ring or core of high salinity water to the east of this maximum penetration. This core can be traced as a distinct feature during August along the Western Florida Continental Shelf until it exits near the Dry Tortugas area and re-enters the Straits of Florida. The width of this core is illustrated in Figure 10.

It should be noted that the maximum salinity values greater than 37.0 °/oo recorded in Figures 22 and 23 are in excess of salinity values previously recorded in Loop Current waters. Dr. W. Nowlin of Texas A and M University (personal communication) has questioned the validity of these values. However, since they were observed in a total of four bottles from three oceanographic casts on two sections, they have been retained and used in the profiling of these figures.

Mississippi estuarine water, as defined by Chew (1955), with TS characteristics of 24.0-30.0°C and salinity of 25.5-36.2 °/oo can be seen entering the area from the west in two distinct eddy patterns. It seems to be a structure identifiable as far east as 86°34' West. Again, as with the Loop Current and Loop Transitional waters, the temperature sections show

little indication of the current structure.

In summary, it appears that in August, 1971, a very complex eddy structure was present from the surface down to between five and ten meters depth, representing the interfaced conditions of the Mississippi estuarine, Eastern Gulf Shelf, Loop Transition and Loop Current waters. Below this depth there was a predominant flow of Loop Current-Loop Transitional waters onto the shelf from the southwest, exiting to the southeast at or near longitude 85°30' West. In general, a flow pattern was observed from the west to the east, turning at Cape San Blas and exiting to the south with little or no transfer into the Big Bend area.

Although there is very little historical current measurement data available, this inferred current regime from the temperature and salinity fields agrees quite well with the result of two major drift-bottle studies. These studies are Tolbert and Salsman (1964) off Panama City and Murphy and Williams (in preparation) off Tampa-Ft. Myers.

The Panama City drift-bottle releases were made monthly, from a single stationary platform in a depth of 30 meters. Analysis of water movement from the drift bottle recoveries indicate that the local transport was influenced by tidal currents and wind stress, with the wind currents having the major effect. The percentage of recoveries agree with the frequency of direction of the wind flow at Panama City. However, while the primary mechanism of surface water transport in the vicinity was the wind, the geographical areas of recovery indicated that drift bottles were transported offshore from the platform. When this occurred, other types of currents became the motivating factor. The recoveries showed that during each of

the 12-month cycles there were non-local drift-bottle movements occurring in a westerly, southerly or southeasterly direction except during August. In August, there was no southerly flow.

The recoveries from the study conducted between 26° and 28° North latitude, from the shore to the 50-fathom line in the Tampa-Ft. Myers area (Murphy and Williams, op cit) also indicate the presence of a multiple eddy system upon the shelf in August. This pattern persisted for both years of the study. From the bottles released along 27°35' North, all recoveries indicated a net transport to the north or northeast. All recoveries outside of the 5-fathom line were picked up along the coastline between Cape St. George and Texas. The releases along the 26°20' North latitude transect were all recovered to the south, except for a few within the 5-fathom line which were recovered to the north. This agrees very well with the data taken in August of 1971. As with the Panama City releases, no recoveries occurred in the Cape St. George-Tampa area except in April and May, and then in a very limited number.

In short, while localized surface transport can be predicted by an understanding of the tidal and wind current phenomenon, there is some amount of long distance transport, which will be dependent upon an understanding of the complex shelf circulation and Loop Current interrelationships. These interrelationships in August of 1971 indicated that if the tidal oscillations or wind currents transported the water offshore to approximately 30° North (the outer edge of the territorial sea), the surface water could be transported

to the south, southeast or southwest. It should be realized that the conditions in August will vary from year to year, and this offshore transport cannot be predicted without a better understanding of the circulation systems. Below approximately five meters, the circulation pattern was predominantly to the east and southeast and within the structure of the Loop Current or Loop Transitional waters.

ESCAROSA I - Territorial Waters of Florida Circulation

Before discussing the circulation as inferred from the temperature and salinity distribution within the territorial waters of Florida, it is appropriate to look at the time series sections taken over a 48-hour period from the entrance of Pensacola Bay to 30°09.8' North (Stations 1-5). These data were collected by the R/V TURSIOPS on sections occupied from the entrance of the Bay southward. Each section was sampled within a four hour and twenty-five minute time period. At the completion of each section, the vessel returned to the entrance of Pensacola Bay. The starting time of each section was related to the predicted tidal conditions on September 14 through 16 at Pensacola. Each of the stations was marked by a fixed buoy.

Under these operational conditions, observations and water samples were collected at each station every six hours and fifteen minutes. These data have been plotted as time series figures for parameters of sigma t, temperature, salinity, oxygen, inorganic phosphorus-phosphate, nitrate, nitrite, silicate; and for the trace metals cadmium, lead, copper, chromium, zinc and magnesium; and for the pesticide values of pp'DDE, pp'TDE, DDE, TDE,

Dieldrin, Endrin, Aldrin and Heptachlor Epoxide.

The distribution of salinity in the surface waters south of the entrance to Pensacola Bay (Figure 27) indicates that the surface waters flowing out of the Escambia system extend a considerable distance offshore in a fairly well defined tongue. Bottom waters show little evidence of such distribution, and the data in Figure 28 indicate that the bottom waters flowing out of Escambia Bay did not extend to Station 28, and might flow toward the west close to shore. The time series figures on physical parameters of sigma t, temperature, and salinity (Figures 29, 30 and 31) show surface oscillation patterns which can be related to tidal phenomena. The solid curves in the time series figures represent the surface values while the dashed curves are the bottom values. The predicted high and low tides on September 14 and 15 were 1200 and 0030 hours respectively.

At maximum outflow from Escambia Bay (1800 hours), the salinity (Figure 31) of the surface waters at Station 1 decreased to 23.86 °/oo at 1300 hours on the 14th of September and reached a maximum value of 31.73 °/oo at 1300 hours on the 15th. The inequality of the diurnal tidal movement of these waters was apparent at the next maximum outflow when the salinity only decreased to 25.92 °/oo on the 16th. The average surface salinity at the inshore station over the observational period was 28.81 °/oo. Variation in salinity decreased with increasing distance from the shore, and at Station 5, the average surface salinity was 31.34 °/oo with a range of 29.06 to 32.03 °/oo. Diurnal variations in the salinity of the bottom waters were apparent only at Station 1, which indicates that the deep waters at this

station are subject to influences originating within the Escambia Bay system. The average salinity of the bottom water at this station was 31.82 °/oo, with a range of 29.44 to 33.33 °/oo. On the bottom at Stations 2 through 5, the variation in the parameters of temperature and salinity was either below the reproducibility of the data collection system or so small that it was impossible to determine any oscillation pattern. The ranges of the bottom temperature and salinity values for Stations 2 through 5 are listed in Table III.

TABLE III

The range of temperature and salinity for Stations 2 - 5.

	Range of	
Station No.	Temperature °C	Salinity °/oo
2	28.54-28.47	33.60-33.73
3	28.40-28.48	33.77-33.80
4	28.38-28.48	33.69-33.80
5	28.42-28.48	33.69-33.81

The correlation coefficient and the linear regression between salinity and distance offshore is presented in Table IV and Figures 32 and 33 respectively.

TABLE IV

The Correlation Coefficent Between

Salinity in the Surface and Bottom Water and Distance Offshore

Salinity	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Section VIII
Surface	0.422	0.950	0.934	-0.810	-0.830	0.880	0.982	0.874
Bottom	-0.171	0.691	0.682	-0.730	0.621	0.673	0.647	0.669

The maximum positive and negative correlations in the surface waters correspond to maximum outflow and inflow respectively, and the changing slope of the lines (Figure 32) reflects the tidal oscillations. It is apparent that the surface waters existing in Escambia Bay on an ebbing tide extend to the south for a distance of 7-8 miles (Station 4) and beyond this lie the "Eastern Gulf Waters". The region between 7-9 miles is termed the "mixing zone"; and "inshore region" for the three stations north of the "mixing zone". Although the regression lines for the correlation of bottom water against distance offshore (Figure 33) tend to to indicate tidal influences, these effects are removed when the correlation of bottom water with distance offshore is calculated for all stations except Number 1. These results are shown in Figure 34.

Because of the diurnal impact on oxygen concentrations (Figure 35), it is difficult to relate the effects of Bay waters on the territorial sea water structure. However, a noticeable change seems to occur in the slopes of the curves between Stations 3 and 4. This location is similar to the discontinuity layer for sigma t, temperature and salinity.

The remaining parameters had linear regression lines constructed only for surface waters, since the above data indicate that with the exception of Station 1 there is little probability that materials entrained in the bottom water of ESCAROSA will be transported south of Station 1.

Figures 36 and 37 depict the diurnal oscillation and linear regression lines for inorganic phosphorus-phosphates in the surface and bottom waters. Table V lists the correlation coefficient of inorganic phosphorus-phosphates in the surface and bottom waters with distance offshore.

TABLE V

The Correlation Coefficient Between Inorganic Phosphorus-Phosphate in the Surface Waters with Distance Offshore

Phosphorus-Phosphate	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Section VIII
Surface	-0.215	-0.788	-0.504	-0.357	-0.341	-0.836	-0.896	-0.230
Bottom	0.889	-0.954	-0.922	-0.831	-0.357	-0.166	-0.703	-0.364

Inorganic phosphorus-phosphate ranged from 0.24 micro-gram-atoms per liter (µg-at/l) to non-detectable amounts (less than 0.03 µg-at/l) in the study area during the observational period. At the inshore station, evidence of a tidal oscillation in the surface waters was weak, except for the period 1200-0600 hours during the latter phase of the study. The observed oscillation in the bottom water was also small at this station. The strongest diurnal variations were noted in the bottom waters at Stations 2 and 3. It is difficult to explain the forces controlling these oscillations, since the variations in salinity in the bottom waters did not extend beyond Station 1.

Strong negative correlations were noted between inorganic phosphorus-phosphate and distance offshore in the surface waters coinciding with periods of maximum outflow from the Escambia system. A moderate positive correlation was present at 1300 hours coinciding with high tide. The influence of the Escambia River system upon the distribution of the phosphorus-phosphate in the waters south of Pensacola Bay was apparent in that the range was greater in the "inshore region" than in either the "mixing" or "Eastern Gulf Waters".

Figures 38 and 39 show the diurnal distribution and the linear regression lines for nitrite-nitrogen in the surface waters. Table VI lists the correlation coefficients of nitrite-nitrogen in the surface and bottom waters with distance offshore.

TABLE VI

The Correlation Coefficient Between

Nitrite-Nitrogen in the Surface and Bottom Waters with Distance Offshore

Nitrite-Nitrogen	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Section VIII
Surface	-0.690	-0.757	-0.646	-0.745	0.286	-0.515	-0.966	0.030
Bottom	-0.053	-0.280	-0.926	-0.687	0.209	0.241	0.162	0.498

Nitrite-nitrogen was generally less than 0.05 µg-at/l in the offshore waters. The waters near the entrance to Pensacola Bay ranged from 0.01-0.14 µg-at NO_2-N/l. An inverse relationship between nitrite and salinity appeared to exist at this station in both the surface and bottom waters. Such a relationship was not apparent at the other stations.

The correlation coefficient between nitrite-nitrogen and distance offshore indicates that the waters flowing out of the Escambia system do exert an influence on the distribution of nitrite-nitrogen for the surface waters in this region.

The distribution of nitrate-nitrogen in the waters south of Escambia is shown in Figure 40. The correlation coefficient between nitrate-nitrogen in the surface and bottom waters with distance offshore is shown in Table VII.

TABLE VII

The Correlation Coefficient Between

Nitrate-Nitrogen in the Surface and Bottom Waters with Distance Offshore

Nitrate-Nitrogen	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Section VIII
Surface	0.306	0.999	0.709	0.763	0.763	-0.037	-0.349	0.204
Bottom	0.122	0.427	0.564	-0.404	0.323	0.665	0.400	0.699

No evidence for diurnal oscillations was apparent in the surface waters except at Station 5. Bottom waters south of Station 1 and especially at the intermediate stations exhibited considerable variation over the observational period. No explanation for these changes is available.

With few exceptions, the correlation coefficient between nitrate-nitrogen in both the surface and bottom waters and distance offshore was positive, indicating that the waters originating in the Escambia system exerted little effect on the nitrate-nitrogen concentration of the waters south of the entrance to Pensacola Bay.

The distribution of silica and the linear regression lines for the relationship between silica and distance offshore is shown in Figures 41 and 42. The correlation coefficient

between silica and distance offshore in both the surface and bottom waters is shown in Table VIII.

TABLE VIII

The Correlation Coefficient Between

Silica in the Surface and Bottom Waters with Distance Offshore

Silica	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Section VIII
Surface	-0.166	-0.864	-0.753	-0.774	-0.836	-0.855	-0.941	-0.663
Bottom	0.457	-0.748	-0.583	-0.024	-0.044	-0.602	-0.311	-0.244

The concentration of silica was generally higher in the surface than in the bottom waters and in both instances tended to decrease with increasing distance offshore. Diurnal variations were especially apparent at Station 1 and 2.

Strong negative correlations were observed in the surface waters with distance offshore coinciding with periods of maximum outflow. The movement of waters towards the Escambia system was reflected in correlations observed (Section IV and V) at 1200 hours.

The distribution of cadmium and the linear regression lines for the relationship between cadmium and the distance offshore are shown in Figures 43 and 44. The correlation coefficient

between cadmium and distance offshore in both the surface and bottom waters is shown in Table IX.

TABLE IX

The Correlation Coefficient Between

Cadmium in the Surface and Bottom Waters with Distance Offshore

Cadmium	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Section VIII
Surface	-0.747	0.325	-0.142	0.598	-0.580	0.771	0.068	0.333
Bottom	0.759	-0.865	0.567	0.153	0.236	-0.338	0.162	-0.774

With few exceptions, the surface waters contained less than 1.0 parts per billion (ppb). The bottom waters in general contained slightly more cadmium than was found at the surface. Surprisingly, the cadmium concentrations have oscillation patterns in them with a 28-hour period. This oscillation is much more pronounced on the bottom than it is at the surface. While the peaks are in phase with an outflowing tide on September 14, these elevations appeared to be present in the incoming tide on September 16. Since there was no evidence for the movement of bottom water beyond Station 1, the factors controlling these oscillations are not clear.

The correlation coefficient between cadmium and distance offshore was moderate to weak in the surface waters and no consistent relationship with distance and time was found. A strong negative correlation between cadmium and distance offshore was present at 1800 hours in the bottom water and as indicated above, no explanation is available.

The distribution of lead and the linear regression line for lead and distance offshore is shown in Figures 45 and 46. The correlation coefficient for lead in the surface and bottom waters with distance offshore is shown in Table X.

TABLE X

The Correlation Coefficient Between

Lead in the Surface and Bottom Waters with Distance Offshore

Lead	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Section VIII
Surface	-0.414	0.942	-0.706	-0.110	0.839	0.584	0.088	-0.123
Bottom	0.699	-0.322	-0.653	0.098	0.190	-0.399	0.085	-0.351

The concentration of lead in the surface and bottom was generally less than 2.0 ppb and no marked variation with time was noted except at Stations 1 and 5. The reasons for the observed variations at the latter station are not clear while at Station 1 the fluctuation

in the bottom water appears to be related to tidal forces.

The correlation coefficient between lead in the surface water and distance offshore shows the influence of the tide, in that at maximum tidal outflow (1800 hours) a strong positive correlation was found.

At 1300 hours on Section IV (high tide), a weak negative correlation was present. In the bottom waters, negative correlations were present at 1800 and 1900 hours which corresponded to the low salinity periods found at Station 1. As was found with salinity, there was no evidence to indicate that the bottom waters exiting Escambia moved past Station 1.

The diurnal distribution of copper and the regression line for copper and distance offshore are shown in Figures 47 and 48. The correlation coefficient for copper and distance offshore is shown in Table XI.

TABLE XI

The Correlation Coefficient Between

Copper in the Surface and Bottom Waters with Distance Offshore

Copper	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Section VIII
Surface	-0.158	-0.288	-0.697	-0.593	0.291	0.305	0.078	-0.294
Bottom	0.747	0.541	0.833	-0.915	0.309	-0.453	-0.981	0.138

Surface and bottom waters generally contained less than 10 ppb of copper. The average concentration in the surface at Station 1 was 2.61 ppb with a range of 0.50-8.50 ppb. At Station 5, the average concentration was 4.72 ppb with a range of 0.90-15.25 ppb with an average of 0.6-13.0 ppb. At Station 3 the average concentration of copper was 8.42 ppb with a range of 0.66-24.60 ppb.

Temporal variations of copper in the surface waters were not clearly related to tidal forces. However, the copper content of the bottom water at Station 1 does appear to be related to the stage of the tide.

The correlation coefficient for the surface waters was moderate to weak and showed no clear relation to distance offshore and time. Copper in the bottom waters, at least during the early phase of the time study, did seem to be under tidal influences.

The distribution of chromium and the linear regression lines for chromium in the surface waters with distance offshore are shown in Figures 49 and 50. The correlation coefficient between chromium in the surface and bottom waters is shown in Table XII.

TABLE XII

The Correlation Coefficient Between

Chromium in the Surface and Bottom Waters with Distance Offshore

Chromium	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Section VIII
Surface	0.313	0.760	0.227	0.789	0.223	-0.669	-0.754	-0.037
Bottom	-0.102	-0.578	-0.643	-0.709	0.961	-0.643	0.245	0.084

No clear relation of variations in chromium concentration with time were found at any of the five stations sampled. The correlation coefficients show that at 1800 hours (Section II) on the first sampling day during the period of maximum outflow a strong correlation (0.760) was present indicating increasing concentration with increasing distance from shore, which indicates that, at least during this phase of the tide, the surface waters exiting Escambia do not influence the quality of the waters in the "inshore region" with respect to chromium. It was noted that this relationship is not consistent however, since some 31 hours later during maximum outflow the opposite situation was found. In the bottom waters, the correlation coefficients generally indicated that the concentration of chromium tended to decrease with distance offshore during the ebbing tide and increase with distance during the flood tide.

The distribution of zinc and the regression lines for zinc in the surface water and distance offshore are shown in Figures 51 and 52. The correlation coefficient between zinc in the surface and bottom water with distance offshore is shown in Table XIII.

TABLE XIII

The Correlation Coefficient Between

Zinc in the Surface and Bottom Waters with Distance Offshore

Zinc	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Section VIII
Surface	0.111	-0.801	-0.610	-0.656	-0.214	-0.660	-0.228	-0.147
Bottom	0.346	-0.093	0.871	-0.248	0.509	0.883	0.248	0.883

The zinc content of the surface waters was generally less than 50 ppb and tended to decrease with increasing distance offshore. The average concentration at the surface at Stations 1 and 5 was 23.7 ppb (range 1.0-88.0 ppb) and 18.7 (range 1.8-115.0 ppb) respectively. The bottom water at Station 1 contained less zinc on the average than the surface water while at Station 5 the reverse was true. The average concentration of zinc in the bottom water at Stations 1 and 5 was 8.4 ppb (range 1.5-28.0 ppb) and 29.6 ppb (range 3.6-152.0 ppb) respectively.

Diurnal variations were present in the surface waters for Stations 1 through 4. The variation found in the zinc content of the bottom waters was particularly apparent at Station 2, 3, 4 and 5 and was apparently independent of that occurring at Station 1.

In the surface waters, the correlation coefficient was generally negative indicating that the zinc concentration decreased as a function of distance offshore for each of the sections. The strength of the correlation coefficient fluctuated as a function of time. At maximum outflow, the correlations were more strongly negative, indicating that the surface waters flowing out of the Escambia system exert an influence on the distribution of zinc in the "inshore region". The correlation coefficient for the bottom waters was generally positive and showed little evidence of being controlled by the zinc content of the waters leaving Escambia.

The distribution of manganese and the regression lines for manganese in the surface waters and distance offshore are shown in Figures 53 and 54. The correlation coefficient

between manganese in the surface and bottom waters is shown in Table XIV.

TABLE XIV

The Correlation Coefficient Between

Manganese in the Surface and Bottom Waters with Distance Offshore

Manganese	Section I	Section II	Section III	Section IV	Section V	Section VI	Section VII	Section VIII
Surface	-0.414	-0.826	0.085	0.976	0.553	0.085	-0.990	-0.331
Bottom	0.833	0.301	-0.763	-0.784	-0.106	-0.744	0.595	-0.528

The manganese content of the surface waters was generally less than 5 ppb. The average concentration at the surface at Stations 1 and 5 was 2.9 ppb (range 0.8-6.4 ppb) and 2.4 ppb (range 1.0-4.4 ppb) respectively. Bottom waters at these stations contained, on the average, slightly higher concentrations of manganese than was present at the surface. The average concentration of manganese in the bottom water at these stations was 3.5 ppb (range 0.8-9.0 ppb) and 4.2 ppb (range 0.8-13.6 ppb) respectively.

Diurnal variations were present at Station 1 which seemed to be related to the state of the tide. This was apparent in the entire water column.

Strong correlations were noted between distance from shore and the manganese concentrations in the surface waters. The strength of the correlation fluctuated from -0.826 and -0.990 at each of the maximum outflows. When the tide was flooding, the correlation ranged from 0.976 to 0.553.

The data for the pesticide times series are not as complete as those for the trace elements. Because of cost factors, it was decided to sample only on all stations of Sections I and IV, and on Station 1, 3 and 5 of Section VIII. These sections were at the beginning of the high tide at Pensacola. However, to determine bay discharge fluctuations over the 48-hour period, samples were taken at both the surface and the bottom of each section at Station 1. Figures 55 and 56 represent the concentrations of the pesticides at Station 1 (a half mile offshore at the entrance to Pensacola Bay).

The results of the "Time Series" study, graphically illustrated in Figures 27 through 56, indicate that the tidal discharges from the ESCAROSA bay system are influencing the surface territorial waters south of the entrance to Pensacola Bay. This influence can be seen in varying degrees on the surface out to seven or eight miles offshore in the salinity, nitrite-nitrogen, silica, lead, zinc, and manganese distributions; and in the bottom waters out to one and one-half to two miles offshore in the salinity, silica, lead, copper and manganese distributions. To determine the depth of this discharge, vertical distributions of temperature and salinity are shown in Figures 57 and 58 along each of the TURSIOPS sections

(Section I through VIII). On the figures, the hydrographic numbers refer to the consecutive numbers assigned to each Oceanographic Cast and are not station numbers (1-5). These sections are based on data from the STD, BT, and Oceanographic Casts. If an STD trace was not available for *in situ* measurements, station curves for temperature and salinity were constructed. A station curve was plotted from the BT data, and its profile was used as a guide in constructing the temperature and salinity curves. The EGMEX contour intervals were changed to 0.5°C in temperature and 0.5 °/oo in salinity. These changes were made to illustrate important features in the distribution and to prevent crowding of the contours.

In general, the temperature distributions do not illustrate the influence of bay discharge at this time of year. The uniformity of the bay and territorial water temperatures make it difficult to differentiate tidal effects from diurnal heating. The vertical temperature section shows a temperature inversion. This feature was noted for the entire 48-hour period to a depth of approximately nine to ten meters. The magnitude of this inversion decreased over the observation period apparently in relationship to the appearance of a tropical disturbance within the area on September 16 and 17.

The salinity distribution, on the other hand, illustrates the effect of tidal discharges. This can be noted out to seven to eight miles offshore and to a depth of eight to ten meters. As expected, this agrees very well with the inversion layer noted in the temperature distribution. Below this depth, the salinity is uniform.

The salinity sections illustrate the inequality of the diurnal tidal motions at maximum outflow by comparing the section for 1810-2441, September 14, with 0130-0605, September 16, 1971. While the salinity values varied, it should be noted that the discharge depth remained the same.

The variations in outflow values of the salinities illustrate a possibility that had to be considered in the planning of the ESCAROSA program; that is, the possible fluctuation in the chemical, trace metals, and pesticide concentrations in the discharges from the Escambia Bay system. It was assumed by the pre-ESCAROSA planning panel that the length of time necessary for trace metals and pesticides to enter into and be discharged from the Escambia Bay system was thirty days. Since that time, mathematical calculations have indicated that the discharge time is fifty-five days (Flood & Associates 1973).

While the discharge rates along the western Florida panhandle are not great (Table XVI, p.92) in comparison to the Mississippi and Mobile River systems (Table XVII, p.93), and do not have a major effect in the local circulation patterns according to Tolbert and Salsman (1964), there are daily variations. These variations and changes in the discharge concentrations of parameter source input to the ESCAROSA bay system could have an effect on the territorial waters when coupled with the tidal oscillations. If such variations are occurring, they could result in the appearance of pockets or eddies in the vertical and horizontal distribution of the parameters if the data are non-synoptic.

To illustrate the local runoff fluctuations, which could effect ESCAROSA I, Figure 59 represents the discharge in cubic feet per second and Figure 60 the gauge height in feet, on the Escambia River near Century, Florida. These data have been furnished to ESCAROSA I through the courtesy of the Water Resources Division, Geological Survey, U. S. Department of the Interior, Tallahassee, Florida.

The daily discharge rates for June, July, August, and September are represented in the figures along with a comparison between the maximum (March - dashed line) and minimum (November - solid line) discharges.

For a period of thirty days (August 15 - September 14) in advance of the ESCAROSA I sampling, the discharge rates at this station were very low, varying between 4190 and 1530 cubic feet per second. The mean discharge rate over this period was 2715. It does not seem likely that such fluctuations in runoff could be affecting the circulation patterns around the entrance of Pensacola Bay.

A pre-ESCAROSA I sampling program was initiated in Escambia and Perdido Bays starting on August 11, 1971. The location of these stations is shown in Figure 7. Determinations were made at weekly intervals for parameters of salinity, iron, cadmium, lead, copper, manganese, mercury, arsenic, and pesticides by the Florida Department of Pollution Control. These data are on file in STORAT.

As part of the inter-calibration program, a number of the duplicate samples were exchanged between the University of Miami, which analyzed the ESCAROSA I samples, and the Florida

Department of Pollution Control, which analyzed the bay system samples. The results of the analyses of these inter-calibration samples indicate that there is an order of magnitude difference for copper and manganese between the R/V TURSIOPS data and the data collected at Stations N-14 and L-42. For this reason, in comparing samples taken by ESCAROSA I and those of the bay system surveys, the latter have been multiplied by an order of magnitude since the difference in values is the result of an analytic technical problem rather than an actual change in concentrations. This topic is further discussed in the section relating to the water trace element distribution.

The values of salinity, cadmium, lead, copper, and manganese taken at the station at the mouth of Pensacola and Perdido Bays are shown in Figures 61 and 62. The solid line represents values taken at the surface, and the dashed line represents values taken at the bottom.

Figure 61 shows data collected at Buoy 10 (Station N-14) at Pensacola Pass with a bottom depth of 15 meters on August 18 and 21 and September 2 and 12. At the times these samples were collected, the state of the tide was either high, or flowing out of the bay, and as such, represents concentrations being discharged into the territorial sea waters. The values of September 12 are compared with the R/V TURSIOPS Sections I and IV data, which were sampled at a similar state of the tide on September 14 and 15.

The salinity profiles show a constant decrease during the pre-sampling program from 36.00 to 30.00 $^{o}/_{oo}$. Based on the lack of major fluctuations in runoff (Figures 59 and 60)

and the summer season, it is difficult to understand why the salinities should decrease. Further, neither EGMEX IV (August 22-23) or ESCAROSA I recorded any salinities greater than 33.5 °/oo near shore. However, it is interesting to note the presence of eddies during EGMEX IV. A comparison of the surface salinities at Station N-14 (30 °/oo) with the R/V TURSIOPS section data (31.18 °/oo) indicates a reasonable agreement. R/V TURSIOPS Section IV indicates a surface salinity of 31.71 °/oo, which is an increase and might explain the inadequacy discussed earlier by a reversal of this observed decreased salinity phenomenon on the pre-sampling program.

Cadmium had an increase in concentration near the end of the sampling period ranging from 0.01 to 0.04 ppb. The latter value of 0.04 ppb agrees reasonably well with the 0.08 and 0.09 ppb observed on the R/V TURSIOPS Sections I and IV.

Lead, on the other hand, showed a rather uniform concentration during the sampling period ranging between 1.0 to 2.0 ppb. The value of 1.0 ppb at Station N-14 on September 12 is in general agreement with 1.14 and 0.60 ppb observed on the R/V TURSIOPS Sections I and IV.

As indicated above, the copper and manganese values in the bay are one order of magnitude lower than on the R/V TURSIOPS sections. Since the inter-calibration results have shown this to be a technical problem rather than a real variation in concentration, the data from Stations N-14 and L-42 have been multiplied by one order of magnitude for the comparison of the bay and R/V TURSIOPS data.

Copper shows a marked elevation between the 18th and 21st of August at Station N-14 and ranged between 0.5 to 6.0 ppb. The September 12 value of 0.5 does not agree with the R/V TURSIOPS Sections I and IV concentrations of 2.20 and 8.50 ppb.

Manganese showed an increase during the sampling period ranging from 0.1 to 2.0 ppb with a large increase at the bottom on September 12. During one week, the values increased from 0.5 to 2.0 ppb. These values of September 12 are in reasonable agreement with the R/V TURSIOPS Sections I and IV data of 1.00 and 1.80 ppb at the surface and 1.49 and 2.60 ppb at the bottom.

Figure 62 represents data taken at the bridge channel at the entrance to Perdido Bay at a depth of three meters, on August 11, 17, and 22 and September 3 and 13. Samples on August 11 and 17 and September 13 were collected when the tide was flowing out of the bay and represent concentrations being discharged into the territorial sea waters. Samples on August 22 and September 3 were taken during incoming tidal flows and therefore represent concentrations entering the bay. Because of the different stages of the tides during collection and the fact that the only sampling of ESCAROSA I taken off the entrance to Perdido Bay (R/V BELLOWS, Section XVI, 0030-0455, September 15, Figure 7) was during an incoming tide, it is difficult to relate the pre-ESCAROSA sampling to possible changes in bay concentrations and their effects on the territorial seas.

Despite variation in the stage of the tides, the values collected during the pre-sampling program at Station L-42 are similar to those values collected at the entrance to

Pensacola Bay for salinity, cadmium, copper, and manganese. In the case of lead, a 60 to 70% increase in bottom concentration was noted on August 17 and September 3.

In summary, it can be stated that concentrations observed at the bay entrance stations do have variations over a four-week period prior to ESCAROSA I. In the case of salinity, cadmium, lead, and manganese, the concentrations observed at the bay's entrance on September 12 and 13 are in reasonable agreement with the values observed on the R/V TURSIOPS at Station 1 on September 14 and 15 during the outflowing tidal stage. In the case of copper, the values are not in agreement. However, Station N-14 showed similar concentrations fourteen days in advance of ESCAROSA I.

The concentrations of cadmium, lead, copper, and manganese on R/V TURSIOPS Station 5 have tidal oscillation patterns with peak values much higher than those associated with any of the pre-sampling or ESCAROSA I discharges from the bays. If these peaks represent fluctuations in the bay concentrations, they must have either a source input time period greater than thirty days or represent a single discharge with a resulting net transport from the bay source to Station 5 of less than one week.

Once the concentrations are discharged from the bays into the territorial sea waters, their net distribution patterns would be dependent upon the resultant effects of the freshwater runoff and tidal oscillations and wind stresses on the density currents present. Examination of Figures 59 and 60 indicates an almost uniform freshwater runoff for 105 days

in advance of ESCAROSA I except for a four-day period between August 1 and 4 (45 days in advance of the sampling) where the discharge rates ranged between 6150 and 9250 cubic feet per second with a mean of 7836. If this is the cause of these high peaks noted on Station 5, it becomes important to look at the transporting mechanisms and the temporal characteristics which would transport such concentrations to Station 5.

As has been noted earlier, historically the surface currents usually flow parallel to the shore, flowing to the east nearly as often as to the west in the territorial waters. If the Loop Current is in an extreme northern extrusion pattern, the territorial sea waters would be affected by the Loop Current during the summer months. Examination of EGMEX IV data with historical Loop Current information indicates that the Loop Current was in an extreme northerly extrusion and would be affecting the territorial waters in the summer months. For this reason, it is reasonable to assume that in July, and possibly June, an easterly moving current flow was occurring in or at the edge of the territorial sea. The EGMEX IV data previously presented clearly indicate that this was the case in August.

Lacking a major runoff effect, this density transport would be affected by the wind stresses and tidal currents. Based on studies performed at Panama City and in other areas of the western Florida Continental Shelf, it appears that the wind currents near shore exert the major effect on the resultant net transport.

A fundamental problem in determining the effect of the wind stress on the current is

the lack of adequate long-term wind data at or near the water's surface. Usually, an attempt is made to relate meteorological data from near-by land weather stations to the area. In the ESCAROSA area, there were long-term meteorological records available from the National Weather Service Office, Pensacola, Florida, Hagler Field. Personnel from the station made available summaries of the weather observations for June, July, August, and September of 1971 and summarized climatologic data over a period of several years.

While the climatologic summary does not show the prevailing wind directions, the mean wind speeds show that June, July, August, and September have the lowest wind speeds with July and August having the minimum. The mean wind speeds were respectively 7.3, 6.6, 6.6, and 7.8 miles per hour. The data for June, July, August, and September, 1971, are respectively 5.9, 6.1, 6.8, and 7.2 miles per hour. The 1971 data are very close to the mean conditions. Further, because of their low values, the effect of the wind stress on the resulting transport would be at a minimum during 105 days before ESCAROSA I, if these figures were representative of the wind stress in the territorial sea waters.

Because the Hagler Field station was located inland and well up into the Escambia Bay system, the shorter term records collected by the Gulf Breeze Research Laboratory of EPA were examined to compare their results with Hagler Field. We wish to express our appreciation to Dr. Tom Duke, the director of the Gulf Breeze Laboratory, for furnishing the original wind speed and wind direction records for September 3 through September 16, 1971.

A comparison of the R/V TURSIOPS data with that of Hagler Field indicated agreement in wind directions 57 percent of the time. In this case, the wind directions were measured to the nearest tenth of a degree. The variations in wind directions were much greater than between the Gulf Breeze Laboratory and Hagler Field. Here five-eighths of the observations had wind differences greater than 45 degrees; however, all differences in wind direction occurred between 1500 and 0600 hours.

During the time period over which chemical and trace element samples were collected on ESCAROSA I aboard the R/V DAN BRAMAN, R/V BELLOWS, and R/V TURSIOPS, the wind directions were predominantly from a southerly direction. Except for 1800 hours on September 14, the wind direction was either east, southeast, south, southwest or calm during the regular three-hourly observations taken at Hagler Field. If one looks at the observations taken between 0900 and 1500 hours, all wind direction components were from the southeast, south or southwest. The predominant direction of flow throughout the entire sampling time or between 0900 and 1500 hours was southeast and south.

In an attempt to determine what the wind stresses on the current systems might have been for 30, 55, and 105 days in advance of ESCAROSA I, the three-hourly observations at Hagler Field were examined for wind speeds and direction. These time periods were selected to agree with the pre-sampling program in the bay systems, the theoretical discharge time of the ESCAROSA bay system, and the runoff data illustrated in Figures 59 and 60. Since

the inter-comparison of data from the R/V TURSIOPS and Hagler Field indicated that the wind directions were being influenced by land effects between 1800 and 0600 hours, the Hagler Field data were examined only for wind direction between 0900 and 1500 hours. The daily three-hourly wind speed records were analyzed in two ways; in one, all of the daily records were used and in the other, only those observations recorded daily between 0900 and 1500 hours were used.

The wind speed records were grouped into three speed categories. These were 0 - 5, 6 - 10, and 11 to maximum miles per hour. The maximum speed observed during the periods was 20 miles per hour. The percentage of the time that the wind speeds fell within these three speed categories is indicated below:

All Daily Observations

Speed Range (mph)	Days before ESCAROSA I 30 days	55 days	105 days
0 - 5	50%	40%	56%
6 - 10	44	54	45
11 to maximum	6	6	8

Observed Between 0900 - 1500 Hours

Speed Range (mph)	Days before ESCAROSA I 30 days	55 days	105 days
0 - 5	24%	27%	32%
6 - 10	60	56	61
11 to maximum	16	17	7

A comparison of the wind data from the R/V TURSIOPS, Gulf Breeze Laboratory and Hagler Field records showed some marked variation in the three-hour observations. However, the mean daily values were in close agreement. The variations in the three-hourly observations were related to the land-sea breeze phenomenon. A comparison of the September 3 through 16 data at the Gulf Breeze Laboratory and Hagler Field indicated that a similar condition occurred with the exception that the wind velocities were much closer together.

The real problem came in the question of wind direction. As so often happens in research, and according to Murphy's Law, the Gulf Breeze Laboratory data recorded wind direction right up to the start of ESCAROSA I at which time the system stopped recording wind direction, although it did record speed. It, therefore, became impossible to correlate the wind observations on the vessels with the weather data from the closest meteorological station to the territorial sea waters off Pensacola. A comparison of the wind direction between Hagler Field and the Gulf Breeze Laboratory indicated that they agreed 62 percent of the time. The remainder of the observations indicated that the wind differed in direction by about 45 degrees. The maximum difference was 90 degrees which occurred one-fifth of the time. It should be pointed out that the Gulf Breeze Laboratory data measured wind direction to the 16 cardinal points so that the data could not be compared any closer than 22½ degrees. Although these differences did occur during the entire observation spectrum, they occurred primarily between 1500-0300 hours.

The wind directions were grouped according to whether they were onshore, offshore or parallel to the coast line. The percentage of the time that the wind was blowing in these three direction categories is indicated below:

Observed Between 0900 - 1500 Hours

Wind Direction (degrees)	Days before ESCAROSA I 30 days	55 days	105 days
315 through 045	22%	23%	20%
045 to 135 & 225 to 315	50	48	42
135 to 225	22	23	31
Calm	6	6	7

In summary, this analysis indicates that during the three time periods under study not only were the wind speeds low but the wind directions were predominantly parallel to shore or onshore. Regardless of which time period considered, approximately 50 percent of the time the wind speeds were five miles per hour or less and 90 percent of the time ten miles per hour or less, and the direction 50 percent of the time was parallel to the coast and 23 percent of the time onshore. The predominantly low wind speeds mean that the effects of the wind stress on the tidal oscillations would be small, and the predominantly onshore or parallel to the shore wind directions would be a deterrent in transporting discharges from the bay systems to the outer limits of the territorial sea waters. Although the percentage figures of the wind direction give a feeling for the long-term net transport, which could

be caused by the wind stresses, a more detailed examination of the daily records indicates that there was no long-term consistency in any one single direction.

The wind conditions and tidal periods observed during ESCAROSA I are quite similar to the conditions described by Tolbert and Salsman (1964) during their 72-hour current survey off Panama City during June. During their observations, the winds were out of the SSW at an average speed of 300 cm/sec (7 mph). They observed a tidal extrusion of 5.5 km (3 nautical miles) and a non-tidal onshore component of the surface current of approximately 7 cm/sec (0.14 Kts). Their observed non-tidal speeds seem to agree generally with the accepted rule that the current speed is approximately two percent of the wind speed.

If one were to apply this rule to the wind speed observed during ESCAROSA I, there should have been an onshore current of between 7 and 14 cm/sec (0.14 to 0.29 Kts). If this rule were applied to the maximum velocity observed during the 105 days of weather observations recorded before ESCAROSA I, the maximum non-tidal wind stress current would be 20 cm/sec (0.4 Kts).

The effects that wind direction and speeds can have on tidal oscillations are illustrated in Figure 63 of a subsurface current drogue (depth of 2 meters) off Shark River in October of 1959. This figure (from Rinkel and Dunlop, 1961) shows an observed tidal extrusion similar to that described by Tolbert and Salsman (1964). The figure illustrates the effects that change of wind speed and direction would have on the orbital path of a water particle under a tidal influence. Further, it points out that the resultant transport of the particle will

be confused and its net transport small unless there is some consistency in the direction of the wind stresses. Even though the particle might oscillate back and forth with the tides over three to four miles, it might remain within that area unless the wind speeds are high and the wind directions constant. As has been pointed out before, these tidal oscillations will create eddies or pockets if the data are non-synoptic as in ESCAROSA I.

If one were to assume that the tidal extrusion's major axis was directly southward from Pensacola Bay; that the wind velocity was 20 knots with a non-tidal wind stress current of 20 cm/sec; that the wind direction was out of the north; and that the length of the tidal extrusion's major axis was three nautical miles (as observed off Panama City), it would take a particle discharge from the entrance of Pensacola Bay 15 to 16 days to reach ESCAROSA I Station 5. As can be seen by a review of the weather data up to 105 days in advance of ESCAROSA I, such consistencies of wind speed and direction were not present for that length of time; further, that the prevailing wind directions and speeds not only would inhibit the movement of a particle southward to Station 5 but would greatly increase the time required for a particle to reach that location.

The data for the tidal ellipse structures described above and illustrated in Figure 63 were taken some distance offshore. Since the runoffs from the Escambia Bay system could cause the extension of the tidal extrusion in excess of three nautical miles, it was felt that the vertical distribution of cadmium, lead, copper, chromium, zinc, and manganese from

the R/V TURSIOPS Sections I through VIII over the different stages of the tides during September 14 through 16, 1971, should be examined to determine the effects of the tide on their concentrations.

The surface and bottom values for these sections have been discussed previously and are illustrated in Figures 43 through 56. Their levels of concentration relate to the different stages of the tides at Pensacola. The appearance of highly elevated concentrations at Station 5, which might or might not be in phase with the tides at Pensacola, and the fact that the analysis of the weather data during ESCAROSA I and 105 days before it indicated that water was being transported toward the shore, suggest that the vertical distributions should be examined not only to determine the extent of the trace metal tidal excursion from Pensacola Bay but to give some idea of whether extrusion of high concentrations observed at Station 5 was coming in at the surface or bottom.

Figures 64 through 69 represent the vertical distributions of the trace metals on the R/V TURSIOPS Sections I through VIII. In these figures, the depths are in meters, and the trace metals are in parts per billion. The HYDRO-STA. NO. is a combined number, which indicates not only consecutive hydrocast numbers for the casts made by the R/V TURSIOPS but the ESCAROSA station numbers as well. These numbers are recorded with the hydro station number first followed by the ESCAROSA station number; i.e., 1-1. On ESCAROSA Stations 3, 4, and 5, additional bottles were placed in the cast at the depth of the thermocline and/or just below it. Sections I and V represent high tide; Sections III and VII, low tide; Sections II and VI,

outgoing tidal flow; and Sections IV and VIII, incoming tide at Pensacola.

Examination of the figures shows that the tidal extrusion is occurring out to a location between Stations 2 and 3, between three and five miles offshore. The tidal extrusion, therefore, is very close to the previously discussed data. This is another indication that the runoffs are not a major factor in the local circulation pattern during ESCAROSA I. Perhaps the most interesting feature of these figures is what appears to be a buffer zone at this location between different concentration levels from different source areas which are interreacting within the territorial sea waters. In most cases there are extremely high concentrations in relation to the bay discharges either along the bottom or throughout the entire water column at Station 5. With rare exceptions, the concentrations at the bottom, i.e. below the thermocline, are much higher than those above it. In the case of cadmium, lead, zinc, and manganese, this is occurring in phase with the tidal stages at Pensacola. In the case of the copper and chromium, this is usually occurring during the time of low tide at Pensacola.

The increase in concentrations below the thermocline at low tide and the appearance of these buffer zones coupled with the results of the wind analysis during and before ESCAROSA would suggest that these high concentrations are not associated with the discharges from the bay systems. As will be seen later, in discussing the distribution of density, the water mass at the edge of the territorial waters is associated with a Mississippi Delta and Mobile Bay

source input. It appears that this high source is impinging the territorial sea waters and is being counteracted by tidal extrusions from the bay.

In summary, there does not seem to be any indication during thirty days of pre-ESCAROSA sampling that there has been a change in the concentrations of trace metals discharged from the bay system. Further, the runoff data shows only one four-day period with a significant increase in the discharge rates. The analysis of the wind data indicates not only low wind stress but also a predominantly directional flow which would carry material into the territorial waters rather than away from them.

Before leaving the time series data to consider the effects of the tidal cycles on the general distribution of the territorial waters, it is pertinent to consider the oxygen distributions of the R/V TURSIOPS sections, since they present an unusual pattern. The construction and notations on Figures 70 and 71 are similar to the trace metals (Figures 64-69). Figure 70 is oxygen in ml/l, while Figure 71 is percent of oxygen saturation. Because of the diurnal effect on oxygen, it is difficult to see tidal extrusions in the data. However, they do show an interesting distribution pattern below the thermocline. For example, the distribution of the 4.2 ml/l isopleth is remarkably uniform regardless of sampling time. In fact, this is characteristic of the entire configuration below the thermocline. It is difficult to explain this, considering that the maximum depth is 25 meters and should not pose a problem in regard to light penetration. This uniformity is even more puzzling when compared to

nitrate distribution (Figure 40). Here one observes complete utilization at the surface but with coincident changes in the concentrations of the bottom nitrates in phase with the tides. Apparently the nitrogen is not being absorbed in the biological processes below the thermocline. This suggests that some consideration should be given to determining the reason for this unusual occurrence and the importance of analyzing the selectivity of the biological processes in the area. This is particularly important relative to biological processes and their reactions with trace metals and pesticides.

A major difficulty in analysis of the plume discharges from the bay systems is the lack of synoptic data. The extent of the detailed sampling area, the resources available and limitations of vessel speed allowed only two sectional sweeps of three sections per sweep during each diurnal tidal phase. To insure continuity of the data, the sweeps were always taken from north to south along longitudinal lines, with the inner stations of each section one-half mile offshore. The first of the three-section sweeps was taken from the entrance of Pensacola Bay westward toward Perdido Bay. After this sweep, the R/V BELLOWS continued to the west while the R/V DAN BRAMAN crossed the R/V TURSIOPS' first section and sampled to the east. This pattern was continued until the R/V BELLOWS reach Section 18 and the R/V DAN BRAMAN Section 9. The sweeps on Section 19 and 20 were only two-section sweeps. This sampling procedure and schedule allowed the data to be collected for each area near-synoptically, over four-hour fifty-five minute periods. Each rectangular area includes data from one

tidal period (24.8 hours) beginning at high tide at Pensacola at 1200 GMT September 14, 1971. Within each of these areas, the data taken on essentially east-west lines are synoptic since the oceanographic cast times for each vessel were coincident. Tidal ebb and flow effects are characterized in these areas by selected parameter measurement over complete tidal cycles, at the surface and bottom of the water column, for appropriate time periods. The physical parameters of surface sigma t, and salinity (Figures 72-74) document the extent and shape of the discharge plumes. As previously discussed, the temperature field does not characterize these features, indicating the almost uniform temperature regime both in the bay and in the territorial sea. The measurement of the southward extension of the plume agrees well with that obtained in the time series data. The effects of an eastward transport are well documented in the discharge from Perdido Bay. This eastward transport agrees well with the EGMEX IV data and the ESCAROSA I wind stress information.

Surface silica (Figure 76), inorganic phosphorus - phosphate (Figure 77), cadmium (Figure 80), zinc (Figure 83), and manganese (Figure 84) exhibit plume structures similar to those of the sigma t and salinity structures. An eastward discharge from Perdido Bay may be observed in the distribution patterns for the parameters silica, inorganic phosphorus-phosphate, zinc and manganese. This is not observed for the cadmium distribution. Lead (Figure 81) exhibits an outflow at Pensacola Bay, but no eastward transport from Perdido Bay. Figures 61 and 62 indicate that the lead concentrations discharged from Perdido Bay

were higher by a factor of 4 than those from Pensacola Bay.

Oxygen (Figure 75), nitrite-nitrogen (Figure 78), and nitrate-nitrogen (Figure 79) do not show a plume structure. These parameters are either effected by diurnal factors and/or associated with biological processes. The extremely low nitrate-nitrogen concentrations which are associated with the discharges from the bay systems suggest that the processes previously discussed relative to this parameter in the Pensacola Bay discharge may also be occurring within the Perdido Bay discharge area.

Copper measurements (Figure 82) indicate the discharge of elevated concentrations from both Pensacola and Perdido Bays. As in the non-tidal variations noted in Figure 47 of the R/V TURSIOPS time series, these concentrations are not following the normal plume structure found in the other parameters.

Sigma t, temperature and salinity values (Figures 85-87) show little evidence of a bottom plume structure. If one is present, it does not extend to more than a mile offshore at Pensacola.

Lead, chromium and manganese (Figures 94, 96 and 97) exhibit bottom plume structures similar to those shown by the sigma t and salinity distribution patterns. Silica and inorganic phosphorus phosphate (Figures 89 and 90) have bottom structures out to three miles offshore. Cadmium and zinc (Figures 93 and 97) have bottom plume structures to five miles offshore. The extension of the trace metal plume structures seaward seems to be associated

with the "buffer zone" described elsewhere in this section. The observed patterns for oxygen, nitrite-nitrogen, nitrate-nitrogen, and copper (Figures 88, 91, 92 and 95) demonstrate no relationship to the observed patterns for sigma t and salinity.

Sigma t, temperature and salinity distributions (Figures 99-101) indicate a bottom discharge from Perdido Bay that is minimal. Even on an incoming tide there is little observed movement of the isohalines which parallel the coast line here and to the east of Pensacola Bay. Since the runoff from the Perdido River is only approximately one-seventh that of Escambia Bay (Table XVII), this is not unexpected.

On the incoming tide, flow patterns for all measured parameters except oxygen appear to be parallel to the coast (Figures 103-112). The trace metal distributions (Figures 107-112) show high concentrations flowing into the area from the west, except for cadmium and copper. Chromium, zinc and manganese distributions indicate that the tidal excursion from Pensacola Bay has created high concentration "pockets" by disrupting the prevailing flow pattern. The plume discharges from Perdido and Pensacola Bays may be identified by the horizontal distribution patterns at both the surface and bottom for the parameters of sigma t, temperature, salinity and oxygen (Figures, 113, 114, 115, 120, 128 and 129). It is necessary, however, to also consider the effects of tidal oscillation (Figures 85-87, 99-101) on these distribution patterns. The eastward movement is best characterized by the parameters sigma t and salinity. This eastward flowing density current is similar to

that noted during the EGMEX IV experiment. These plumes are a surface and near-surface expression. Temperature field variations are a poor indicator of this transport. The distribution patterns here discussed document an easterly flow on the western edge of the study area, exhibiting a structure derived from still farther west, and similar to the plume discharges associated with Perdido and Pensacola Bays. Unlike the plume structures associated with these bays, this structure can be observed at both the surface and bottom. The structures extend to the outer edge of the territorial sea, where tidal oscillations may carry the water into the Loop Current, which was located at the outer limit of the territorial sea during the EGMEX IV experiment.

The time series data shows conclusively that the plume discharges at Perdido and Pensacola Bays are restricted to the water column above the thermocline. To better examine and define the characteristics of these plumes, horizontal sections of temperature and salinity were plotted (Figures 116-119, 121 and 124). Evaluation of these sections clearly show the Perdido and Pensacola plumes restricted to the area above the thermocline. The eastern flow is well documented. The effects of the waters impinging from the west, derived from Mobile Bay and/or the Mississippi River may be clearly seen. Figures 125-127 illustrate the vertical salinity and temperature distribution along section lines 9 to 20. The temperatures do not show the eastward transport or the effects of the plume discharges from the bays. The salinities, however, do show these features and their vertical restriction to waters above the thermocline.

The measured vertical distribution patterns from the R/V TURSIOPS data are shown in Figures 57 and 58. The TURSIOPS time series sections and the sections shown in Figures 125-127 relate to the tidal phases at Pensacola in the following manner: Sections 1, 4, 9, 13, 14 and 18 were taken at high tide; Sections 2, 6, 12, 15 and 19 were taken at maximum tidal outflow; Sections 3, 7, 11, 16 and 20 were taken at low tide; and Sections 5, 10 and 17 were taken at incoming tide. When these sections are analyzed relative to the tidal phases, certain characteristics are apparent. At high, low and outflowing tide, there are surface pockets of low salinity water present five to seven miles offshore between Mobile Bay and Section 12. This is the same location noted in the trace metal tidal excursions on the R/V TURSIOPS time series. In the case of incoming tidal flows, there are relatively higher salinities moving into this area, with a displacement of the pockets of low salinity water toward shore, except on Section 4 of the R/V TURSIOPS time series. These features appear to confirm the presence of a "buffer zone" located five to seven miles offshore, as also noted in the discussion of trace metal distribution. This zone is limited to the area of the water column above the thermocline.

In summary, there are characteristic plume structures existing in the water column at Mobile, Perdido and Pensacola Bays. The outgoing tidal flow from these discharge areas is moving toward the east and parallel to the shoreline. Except for Mobile Bay, the plume discharges do not completely cross the limit of the territorial sea of Florida. In the case of the discharge from Mobile Bay, it does. Further, there are tidal oscillation

patterns which are amplified by wind stress action bringing water masses from south of the territorial sea into the area. High concentrations of trace metals at Station 5 from the R/V TURSIOPS time series can be related to values observed in the Mobile Bay plume discharge, and are coming in at both the surface and bottom at Station 5.

Distribution of Nutrients

The distribution of inorganic phosphorus-phosphate (Figure 130) in the surface waters off ESCAROSA, with the exception of the waters flowing into the area from the west, was generally less than 0.2 ug-at/l. The lowest concentration appeared to originate from the waters flowing out of the Escambia River. The highest concentration (9.59 ug-at/l) was found in a single sample from waters flowing from Mobile Bay.

Phosphate present in the bottom waters (Figure 131) showed distribution patterns similar to that found in the surface waters.

A direct comparison of the distribution patterns found in the surface and bottom waters shows evidence of a lag effect, which is attributed to the time delay between surface and bottom water movements. It was also noted, that contrary to the patterns found for trace elements and pesticides, no well-defined eddy effects were present.

Nitrite concentrations (Figures 132-133) were high (0.49 ug-at/l) in both the surface and bottom waters. The reason for this is not clear at this time, although it was noted that these concentrations do not appear to originate from either the Escambia or Perdido River systems.

Nitrate-nitrogen (Figures 134-135) concentrations were low in offshore waters. The highest concentrations (0.19 - 0.73 µg-at/l) were present in the waters flowing from the west. Although a rather complex distribution pattern of nitrate was present in the surface and bottom waters, the data indicate that the water flowing out of both the Escambia and Perdido Rivers was deficient in nitrate-nitrogen.

The surface waters of these rivers contained elevated concentrations of silica (3.1 - 11.3 µg-at/l, Figure 136), and it is possible that this element could serve as an indicator of the distribution of these waters in the offshore area. Surface waters entering the study area from the northwest were also enriched in silica.

Bottom waters (Figure 137) entering the region from the northwest and southeast contained high concentrations of silica (9.4 - 13.3 µg-at/l).

Distribution of Trace Metals in the Water

Six trace metals were measured from water samples in this investigation: cadmium, lead, copper, chromium, zinc and manganese. The results of these measurements, in parts per billion (ppb), are shown in Appendix VI. The observed concentrations have been plotted for each station for surface and bottom waters, and appropriate isopleths, as discussed in the analytical methods section, have been drawn (Figures 138-149). Although these data represent only a single limited time period, the contours indicate the occurrence of certain events in the Florida territorial sea off ESCAROSA, and also establish the level of

concentration for each of these elements at the time of sampling.

With the exception of the copper concentrations, the average measured values of the five other trace metals were approximately ten times the concentrations typically observed in open-ocean waters. This indicates an enrichment of these trace metals in the shelf waters by effluents from undetermined inshore sources. Examination of the distribution pattern for each element indicates a large tongue of water moving into the ESCAROSA area from the west, possibly from Mobile Bay or the Mississippi River. For example, analysis of the cadmium concentration values in the surface waters indicates two eddies containing relatively high concentrations, with no apparent connection to the mouths of either Perdido or Escambia Bay. The surface waters at the western edge of the area were uniformly enriched while the waters at the eastern edge intermittently contained high levels of this element. This pattern generally holds true for the other trace metals measured. The distribution of cadmium in the bottom waters differed from surface distribution values primarily by the presence of a well-defined eddy of cadmium-rich water lying to the south and midway between Perdido and Escambia Bays. The observed levels indidate that these waters are influenced by runoff from Escambia Bay, as well as offshore waters. The distribution pattern also indicates an intermittent source, as well as tidal influence. The bottom waters to the west and east were also enriched. The average concentration of cadmium in the surface waters was 0.181 ppb, with a range of 0.02 to 1.66 ppb. The bottom water average concentration was

0.186 ppb, with a range of 0.01 to 1.46 ppb (Figures 138-139).

Surface waters emerging from both Escambia and Perdido Bays contained elevated concentrations of copper. The same eddy effect noted for cadmium was found in the offshore copper distribution as well. The surface waters both to the west and east contained elevated concentrations of copper. An apparent enrichment of this metal in bottom waters exiting Escambia and Perdido Bays is shown. Average measured concentrations and ranges of copper in surface waters were 1.658 ppb and non-detectable to 3.25 ppb, respectively (Figures 140-141).

Chromium exhibited a more uniform distribution in surface waters than did either cadmium or copper. Waters exiting both Escambia and Perdido Bays generally contained more chromium than those in the rest of the study area. High concentrations were also found in all other sampled areas. The bottom water distribution pattern of the chromium was more complex than that at the surface. Highest concentrations were generally measured in the areas south of Escambia and Perdido Bays. No indication for western bottom waters as the source of these values was found. A single high value of 50.5 ppb was measured at the eastern edge of the study area. It could have been the result of past contributions to the offshore waters from the river systems, or from the Mississippi River (Figures 142-143). The average measured concentration and range of chromium in the surface and bottom water was 1.087 (0.20 - 2.19) and 2.01 (ND - 58.50) ppb, respectively.

An input of lead to the shelf waters off ESCAROSA is derived from the surface and bottom

waters flowing from the northwest. Bottom waters at the southern margin of the study area also show elevated lead levels. Surface waters exiting Escambia Bay did not contribute lead to the outer area of study at the time of sampling. As noted in regard to the other measured metals, the distribution of lead in both surface and bottom waters is tidally influenced (Figures 144-145). The average concentration and range of lead in the surface and bottom waters was 0.471 (0.09 - 1.20) and 0.733 (0.04 - 4.25) ppb, respectively.

Major variations were noted in the distribution of manganese in both surface and bottom waters. Waters flowing from the northwest at the surface, and from west to northwest near the bottom, as well as surface water exiting Perdido Bay, exert a major influence on the concentration and distribution of manganese in the area. With minor exceptions, manganese was uniformly distributed throughout the rest of the water column in the region (Figures 146-147). The average concentration and range of manganese in surface and bottom waters was 2.304 (0.32 - 6.53) and 5.318 (0.41 - 14.45) ppb, respectively.

The distribution of zinc was similar to that observed for lead except that the major input sources off ESCAROSA were Perdido Bay and from the northwest. This effect was noted in both surface and bottom waters (Figures 148-149). The average concentration and range of zinc for surface and bottom waters was 7.556 (0.16 - 21.13) and 14.959 (2.26 - 36.50) ppb, respectively.

A comparison of the trace metal concentrations found in the Perdido and Escambia Bay

areas by the Air and Water Pollution Control Laboratory with the analyses from the offshore area reveals certain similarities and differences. It would be expected that trace metal concentrations of the waters at Channel Pass from Perdido Bay (Station 5) would resemble the offshore waters of Section 16, and in many ways, the concentrations are alike. The cadmium concentrations at Channel Pass varied from 0.01 to 0.04 ppb, while offshore waters varied from 0.02 to 0.07 ppb. The lead concentrations at Channel Pass were slightly higher (1.0 - 6.0 ppb) than the concentrations in the offshore waters. The copper concentrations as measured by the two laboratories differ by as much as one order of magnitude. For example, the copper concentration measured at Station 5 (Channel Pass) by the Air and Water Pollution Laboratory varied between 0.05 and 0.3 ppb while data from the ESCAROSA study showed concentrations between 1.0 and 2.0 ppb. This latter concentration is barely above the concentrations found in the open sea. The differences in the two measurements probably relate to the fact that one laboratory measured only the ionic copper while the other measured total copper. Copper in the marine environment exists primarily as an organic complex with ionic copper representing only 10-20% of the total.

Distribution of Trace Metals in Sediments

The metal concentrations, with the exception of cadmium, for the study area are shown in Figures 150-159. The analytical data pertinent to these metals are contained in Appendix VI.

Cadmium was detectable in 14 of the 40 samples analyzed. In 13 of these 14 samples, the concentration was equal to or less than 1.0 ppm. The remaining sample, collected just inside the entrance to Pensacola Bay, contained 3.0 ppm. Tin showed little variation between the inshore areas (Perdido and Escambia Bays) and offshore. The average concentration of tin for the entire study area was 5.0 ppm, with the highest concentration (21.0 ppm) present in a single sample collected at the junction of Escambia, East and Pensacola Bays. One offshore station, C14, and one station in the upper reaches of the Perdido River, C29, contained 12.0 ppm. The range of tin in the sediments was from non-detectable to 21.0 ppm (Figure 159).

As indicated in the figures, the concentration of the other measured trace elements (Hg, Fe, Mn, Cr, Zn, Co, Cu, and Pb) was generally lower in Perdido and Escambia Bays. Insufficient data prevented such a comparison for cadmium in Perdido Bay. No significant differences at the 95% confidence level were found when the lead content of the sediments in Escambia Bay was compared to the lead content of the offshore sediments, while the converse was true for the offshore sediments versus the Perdido Bay sediments.

Only the iron, manganese and lead content of the sediments in Escambia Bay were significantly different from those of the Perdido River. No significant differences were found for the remaining metals (Hg, Ni, Cr, Zn, Co, and Cu) when the two river systems were compared.

It is readily apparent from an examination of the figures that little, if any of the sediments in the Escambia Bay and Perdido River systems are moving out of the bay. Evidence for this is obtained from the lowered trace element content of the sediments near the mouth of these two systems. The concentrations found in these sediments are similar to those found in the offshore sediments.

The correlation coefficient of the regression of these metals with iron, in each of these systems (Escambia and Perdido Bays, and offshore) was calculated. These results are shown in Table XV.

TABLE XV

Correlation Coefficient of the Regression

of Selected Elements with Iron in the Sediments

	Hg	Ni	Mn	Cr	Zn	Co	Cu	Pb	Sn
Perdido	0.899	0.796	0.876	0.914	0.907	0.675	0.867	0.554	0.429
Escambia	0.521	-0.588	0.908	0.800	0.694	-0.306	0.241	0.773	0.711
Offshore	-0.384	-0.052	0.579	0.464	0.334	-0.071	-0.300	-0.498	0.052

In the offshore sediments, moderate correlations were found between manganese, chromium and zinc with iron. A weak correlation was found between tin and iron. Mercury, nickel,

TABLE XVI

Drainage Areas and Average Flows of Streams
in Escambia and Santa Rosa Counties, Florida
(Musgrove et al, 1965)

River Basin	Drainage Area (square miles)		Average Flow (million gallons per day)	
	Total	In Escambia and Santa Rosa Counties	From Basin	From Escambia and Santa Rosa Counties
Perdido River	925	236	*1,120	**284
Brushy Creek	75	53	90	65
McDavid Creek	34	34	40	40
Jacks Branch	24	24	16	16
Bayou Marcus Creek	26	26	*60	**60
Carpenter Creek	18	18	*20	**20
Escambia River	4,233	410	*4,540	**556
Pine Barren Creek	98	85	134	116
Moore Creek	32	32	40	40
Canoe Creek	37	24	50	30
Blackwater River	860	580	*960	**710
Pond Creek	88	88	80	80
Big Coldwater Creek	241	228	350	330
Big Juniper Creek	146	134	170	155
Yellow River	1,365	115	*1,620	**136
Coastal Drainage	300	300	*220	**220

*Total Flow into Bays 8,540
**Total Flow from Counties 1,986

TABLE XVII

Discharge and Load Data for Major Rivers Tributary
to the Northeastern Gulf of Mexico
(Griffin, 1962)

River System	Drainage Area (sq mi)	Average Discharge (mill gal/day)	Average Suspended Sediment Conc. (ppm)	Suspended Sediment Load (mill tons/yr)
Mississippi (total)	1,243,600[1]	309,000[2]	250[2]	213[2]
Directed to E. Gulf*		(92,700)		(64)
Mobile	43,000[3]	39,300[3]	48[3]	(5)
Apalachicola	18,800[5]	14,000[4]	(80)	3[5]

References: [1]USGS Circ. 387; [2]USGS Circ. 374; [3]USGS Circ. 373; [4]USGS Water Supply Paper 1002; [5]USGS Water Supply Paper 234.

Figures in parentheses are approximations computed from published data.

*Approximately 25-35 percent of the Mississippi's flow is deflected toward the eastern Gulf (Scruton, 1956).

cobalt, copper and lead appeared to be independent.

In the Perdido River, strong correlations were found between mercury, nickel, manganese, chromium, zinc, cobalt and copper with iron. Escambia Bay correlations differed from those of the Perdido River in that the nickel and cobalt content appeared to be independent of iron concentration. Strong correlations were noted between the remaining trace metals and iron, with the exception of copper which showed a moderate correlation.

The higher concentration of iron found in the sediments of the upper reaches of the two river systems, with the above correlations, indicate that physico-chemical factors occurring in the water column are causing the precipitation of iron in these regions, with the consequent co-precipitation of the associated metals. The mechanisms for the deposition of nickel and cobalt remain to be clarified.

Distribution of Pesticides

Figures 160-176 depict the distribution of the pesticides in parts per trillion (ppt) found in this study in both the surface and bottom waters. Two additional figures showing the measured distribution of the various Aroclors are shown in Figures 177 and 178.

Elevated concentrations of op'DDT were found in the surface waters south and slightly west of the Perdido River. The concentrations in this area ranged from an average of 16.7 to 138.0 ppt. In the bottom waters, the concentration of op'DDT ranged up to 255.9 ppt. At the eastern edge of the study area, the concentration of this pesticide ranged up to

approximately 31 ppt. The concentration present throughout the rest of the water column ranged from traces to 7.9 ppt (Figures 160-161).

Of the 77 samples of surface water checked for the presence of pp'DDT, less than 20 percent contained measurable quantities of the pesticide. Concentrations above 10 ppt were found in waters immediately adjacent to the shoreline west of the entrance to Pensacola Bay (30.9 ppt), and at the northeast corner of the study area (14.2 ppt). The bottom waters also showed little evidence of the presence of this pesticide with two exceptions. The waters located between $87^{o}40'W$ and $87^{o}50'W$ longitude and $30^{o}05'$ to $30^{o}10'N$ latitude contained concentrations ranging from 34.5 to 309.5 ppt. Bottom waters located at the southeast corner of the region also showed higher concentrations with amounts ranging from 10.2 to 35.7 ppt (Figures 162-173).

Well-defined eddies of DDE were located in both the surface and bottom waters in the same region that higher levels of op'DDT had been found. The water column in this area contained amounts of this pesticide ranging up to 14.3 ppt. The remainder of the waters in the study area generally contained less than 3.6 ppt (Figures 164-165). Both the surface and bottom waters to the east of Pensacola were enriched in pp'DDE. Concentrations ranged from 4.5 to 10.1 ppt in the surface waters and up to 37.4 ppt in the bottom waters. In addition to this value, a high concentration (2816 ppt) was found in a single sample collected from the outermost station southwest of the Perdido River. Values less than 4.0 ppt

of pp'DDE were found in the rest of the study area (Figures 166-167).

The surface and bottom waters south of the Perdido River contained higher concentrations of pp'TDE than other offshore waters. The levels of pp'TDE found in this region ranged from 14.3 to 71.4 ppt, while in the rest of the region, with the exception of the eastern edge, the pesticide was generally present in trace amounts, or non-detectable. At the eastern edge, pp'TDE ranged up to 17.5 ppt (Figures 170-171).

Measurable quantities of Dieldrin were generally present throughout the offshore waters in amounts ranging from trace quantities to 71.4 ppt in the surface waters and from trace quantities to 34.5 ppt in the bottom waters. The observed pattern of distribution is apparently under strong tidal influence and appears to be related to discharge from the Escambia and Perdido Rivers. Evidence of an additional input at the surface from the northwest, and in bottom waters from the southwest was evident (Figures 172-173).

Aldrin was present only in trace quantities at the surface. In bottom waters, it was present in levels above trace only at two stations near the western boundary of the study area, where concentrations ranged from 17.2 to 19.0 ppt (Figure 174).

Heptachlor epoxide was present in levels above trace in one large cell of surface water located south of the Perdido River and at the mouth of the Escambia River. Two smaller cell-like structures were located at the southwestern and eastern edges of the study area. Concentrations of 18.6 ppt heptachlor epoxide were present in the surface waters flowing out of

Escambia Bay and of 18.9 in the bottom waters. Eddies of water containing elevated concentrations of the pesticide were also observed (Figures 175-176).

Endrin was undetectable in both the surface and bottom waters throughout the study area.

Aroclor 1254 was found in five of the surface samples. An additional station contained Aroclor 1248. In the bottom water samples, eight contained Aroclor 1254; and one station contained Aroclors 1248 and 1260, in addition to 1254 (Figures 177-178). While all the pesticide values are in parts per trillion, the Aroclors are reported in parts per billion (ppb) concentrations.

The source of the PCB's is not clear at this time. The possibility of contamination of these samples from the plastic sampling bottles was considered. These same bottles were used throughout the investigation, however, and no evidence of the presence of PCB's in the other samples collected in this study was found. A more probably source is industrial pollution. It is apparent from the data that with few exceptions, namely Aldrin in the surface waters and Endrin through the water column, the waters off ESCAROSA are contaminated to varying degrees with the remaining pesticides.

Appendix VII is the result of the determination of the pesticide values.

Geology

Sedimentology

The size frequency analysis and measurement of the percent fine material (smaller than 62 microns) provide a general pattern for the sedimentary phenomena analysis within the study area. The details of this pattern may be derived from the tabular statistical parameters in Appendix III and from Figures 179-182. The verbal description of each sediment sample is included in Table XVIII.

The general pattern of sedimentation may be summarized as follows. The offshore section consists of very fine to coarse sands with the majority of the sediment in the fine-to-medium range. A major exception to this general pattern in the offshore area is a region of very fine sand nearshore in the westernmost section, probably a result of the influence of the intrusion of waters from the west, originating in Mobile Bay and environs. A high organic content (Figure 179) is also observed in this region, as would be expected from waters derived from this source. The sigma t values indicate an easterly current flow in this region as well. The documentation, therefore, of Mobile Bay waters intruding into this region from the west seems to be well authenticated. Another major anomalous region, from the sedimentary standpoint, is an area of fine sand surrounded by medium to coarse sands (Figures 180-181) approximately in the middle of the offshore section and slightly to the east of the mouth of Escambia Bay and Santa Rosa Sound. This area coincides with a well-defined upwelling region,

TABLE XVIII

Verbal Sample Descriptions

Note: Size analysis done only on coarse fraction (greater than 62 microns)

Sample No.	Description
1	medium sand, moderately well sorted
2	fine sand, moderately sorted
3	fine sand, moderately sorted
4	medium sand, moderately sorted
5	medium sand, moderately sorted
6	fine sand, moderately well sorted
7	medium sand, poorly sorted
8	coarse sand, poorly sorted
9	fine sand, moderately well sorted
10	medium sand, moderately sorted
11	medium sand, moderately well sorted
12	medium sand, moderately sorted
13	fine sand, moderately well sorted
14	medium sand, moderately sorted
15	medium sand, moderately well sorted
16	medium sand, moderately well sorted
17	medium sand, moderately sorted
18	medium sand, poorly sorted
20	fine sand, moderately well sorted
21	medium sand, moderately sorted
22	medium sand, moderately sorted
23	medium sand, moderately sorted
24	medium snad, moderately well sorted
25	medium sand, moderately sorted
26	medium sand, moderately well sorted
27	medium sand, moderately well sorted
28	medium sand, moderately well sorted
29	medium sand, moderately sorted
30	medium sand, moderately well sorted
31	medium sand, moderately well sorted
32	medium sand, well sorted
33	fine sand, moderately well sorted

TABLE XVIII (contd)

Sample No.	Description
35	fine sand, moderately well sorted
36	medium sand, moderately well sorted
41	fine sand, well sorted
43	fine sand, moderately well sorted
45	fine sand, moderatley sorted
48	fine sand, moderately well sorted
50	fine sand, moderately well sorted
51	medium sand, moderately well sorted
61	69% fines (silt to clay), coarse fraction very fine sand, poorly sorted
62	fine sand, moderately sorted
63	fine sand, moderately well sorted
64	fine sand, moderately well sorted
65	fine sand, moderately well sorted
C25	medium sand, moderately sorted
C26	fine sand, moderately sorted
C27	medium sand, well sorted
C28	medium sand, moderately well sorted
C29	89% fines; coarse fraction-coarse silt to clay, very well sorted
C30	50% fines; coarse fraction-very fine sand, poorly sorted
C37	very fine sand, very well sorted
C38	medium sand, poorly sorted
C39	87% fines; coarse fraction-coarse silt to clay, well sorted
C40	99% fines (silt to clay), very well sorted
C42	86% fines; coarse fraction-silt to clay, very well sorted
C43	99% fines; silt to clay, very well sorted
C44	98% fines; silt ty clay, very well sorted
C45	fine sand, moderately sorted
C46	22% fines; coarse fraction-fine sand, poorly sorted
C47	47% fines; coarse fraction-very fine sand, moderately sorted
C48	medium sand, moderately sorted

characterized by high trace metal concentrations as well as anomalous physical oceanographic characteristics. In the bay areas themselves, it is apparent that, in general, the sediment ranges from a fine sand to mud. Thus, the bays act as fine-sediment traps, effectively blocking the runoff of much of the silt and clay size material introduced into them by rivers and runoff from the surrounding land area. Relatively high organic values were also observed in the bay areas, as would be anticipated in this "barrier" situation. An interesting contrast may be observed between the upper and lower bay samples, where it is apparent that a high percentage of organic materials are trapped in the upper bay, and that there is a much stronger flushing action by currents in the lower bay area where both the fine-fraction percentages and organic percentages fall to significantly lower levels than in the upper bay. It should be observed that there are a number of "anomalous" values in all the parameters measured, appearing in a number of samples not necessarily coincident. It is reasonable to assume that the collecting methods used occasionally obtained a sample which either was atypical of the bottom or which was altered significantly from the standpoint of its sedimentary properties through the collection method utilized. This is an expected occurrence in dredging for samples, where there is relatively little sample control, as well as little opportunity to determine whether a sample has been significantly altered by the collection method due to selective washing-out of a particular size fraction of the sample. Precise sedimentary

sampling requires the use of some sort of coring device, which retains the sediment sample in its approximate "natural" bottom position and character after collection. The data presented here however, are accurate within the limits of the sampling and analytical methods utilized and are at an appropriate accuracy level for the general conclusions here presented.

It should be well understood, and is here emphasized, that the general statements regarding the offshore sand distribution pattern and the effective fine-sediment trapping ability of the bays is not an original observation, but has been previously, and frequently, made by previous investigators. The relationships between the sigma t values, trace-element distribution, and sediment grain-size distribution patterns and percent organic material has, however, been characterized and related for the first time in this report. It is apparent that offshore water movement, particularly from the west and presumably from Mobile Bay, has a far greater influence on the distribution of the measured sedimentary parameters in this study than does the runoff from the ESCAROSA area. The one exception to this is the rather restricted area of high trace-element values coincident with a finer size sediment in the documented eddy, or gyre, occurring offshore of the mouth and slightly to the east of the bay system.

The percent carbonate distribution pattern (Figure 182) shows generally minimal values in the western portion of the area and in the bay region in general, with only two major

anomalies (samples C37 and C43). Increasing carbonate percentage values occur to the east, reaching a maximum between samples 18 and 20 in Section 2. There is a well-defined, high-carbonate development from approximately two to five miles offshore beginning near the mouth of the bay system and running parallel to the shoreline to the eastern boundary of the study area. This relatively high "zone" of carbonate concentration probably continues to the east well beyond the limits of the study area in approximately its same relative offshore position.

Sources and Dispersal of Clay Minerals as Related to the Movement of Particulate Pollutants

Among the many gaps in our knowledge of fine-grained sediments is an adequate understanding of the source and dispersal pattern of the very fine-grained natural and man-contributed particulate matter in the river-bay-shelf system. If we are to establish rational limits on effluents of various types, we must be able to distinguish adequately and quantitatively between the natural and artificially induced particulate contributions. To do this, we must have data on the types and amounts of particles introduced by the natural system and the processes that disperse them. We must also determine the specific types of influx produced by various developmental activities, and the dispersal paths followed by these particles. Finally, the chemical interactions between the surface active clay minerals and the artificial effluents must be determined in order to assess the ability of the natural system to complex with and remove contaminants as part of the sedimentary process.

In the present study, we have certainly not done all of the above for the ESCAROSA area. We have, however, at least developed an initial understanding of the type of dispersal pattern of the clays in the ESCAROSA region and have identified some of the specific problems that can be answered with additional sampling.

Clay minerals, the particles studied here, are inorganic aluminum silicates produced by the natural chemical weathering of pre-existing minerals. The typical clay minerals occur only in the smallest size fractions of soils and sediments. Their upper size limit is typically near 0.002 mm (2 microns), and their lower size limit grades imperceptibly into the colloidal-ionic range. Internally, they have a layered structure leading to a flaky external shape. Also, due to ionic substitutions and ionic dislocations within their crystal lattices, their large surface areas have net negative electrostatic charges that cause them to react with numerous actions. The same type of electrical imbalance causes some of them to complex with organic molecules, particularly with positively charged and/or dipolar organics. It is the latter property that allows some clays to act as decolorizing agents for oils in industrial processes, selectively absorbing undesirable contaminants, especially polar and charged molecules. The extremely small size and flaky shape of clay mineral particles means that they settle extremely slowly and can be transported readily by water currents at least as slow as 0.1 cm/sec (Hjulstrom, 1939). Therefore, the ultimate dispersal pattern of distinctive clay mineral species in the bottom sediments is a function of the net circulation pattern of the

water mass that transported them. More directly, the distribution pattern of the clays delineates the dispersal pattern that will be followed by fine-grained particulate effluents in the bays and on the shelf and the flushing efficiency of the bay system. It further indicates whether or not the particulate effluent system of the bay is connected or disconnected to the open Gulf system.

Three major rivers supply most of the clay mineral detritus that the northeastern Gulf of Mexico receives (Figure 183). The composition of the clay supplied by each river is a product of the weathering versus parent-rock interplay in their drainage basins. In the western drainage basins, erosion and transportation of essentially unaltered montmorillonite prevails. Eastward, weathering becomes more effective, and kaolinite gradually becomes more abundant in the soils and river clays. Consequently, the Mississippi River is contributing a montmorillonitic clay-mineral suite, and the Apalachicola River is contributing a kaolinitic suite. The Mobile River, between these two rivers, is contributing an intermediate clay-mineral suite. The suspended river sediments pass through the various bays and estuaries with only minor alterations in their clay-mineral suites. The only clearly defined alteration is loss in Apalachicola Bay of some of the swelling of the vermiculitic part of the Apalachicola River clay. Other apparent alterations, such as at the mouth of Mobile Bay, are attributable to offshore dilution by Mississippi-derived clay rather than chemical alteration of the clay particles. Within the Gulf of Mexico, the suspended sediment is distributed by

wind-driven shallow water currents and semi-permanent oceanic currents. The result is a pronounced westward drift of kaolinitic Apalachicola-type clay in the littoral zone, and an eastward drift of montmorillonitic Mississippi-type clay in the zones further offshore. Using clay mineral peak height ratios, especially the 15A/7A (mostly montmorillonite/ kaolinite) ratio, the effluent contribution of Apalachicola and Mississippi clays has been delineated over the entire eastern Gulf of Mexico with the exception of the west Florida shelf (Figure 184, from Griffin, 1962).

The ESCAROSA area, as the term is used here, includes the water of: the Perdido, Escambia, Blackwater and Yellow Rivers, plus several lesser streams; Perdido, Escambia, East and Pensacola Bays; Santa Rosa Sound and its westward extensions; and the littoral and inner zones of the Continental Shelf immediately south of Escambia and Santa Rosa Counties, Florida. The locations of samples used in this project and names of major water bodies are shown on Figure 7 for offshore samples and Figure 8 for the bay samples. All of the streams entering this area are small, the chief one being the Escambia River (Table XVI, after Musgrove, et al, 1965). For comparison, Table XVII (after Griffin, 1962) lists equivalent data, plus other data on suspended loads, for the larger eastern Gulf rivers.

No data on suspended sediment concentrations, loads, or total contributions are known to exist for the ESCAPOSA rivers, thus no definite budget can be computed for their suspended sediment influxes. Casual observations, however, plus published data on their water color

and other quality parameters suggest that the total quantity of suspended sediment, including clay minerals, must be quite small. The total stream flow into Escambia Bay is only 7340 million gallons per day (mgd), and into Perdido Bay only 1200 mgd; these values are respectively 19 and 3 percent of the Mobile River flux. Assuming the same suspended sediment concentration as the Mobile River leads to estimates of 0.95 million tons per year suspended load discharged into Escambia Bay and only 0.15 million tons per year into Perdido Bay. Actually, these estimates are likely on the high side because the ESCAROSA streams are visibly less turbid than the Mobile River. Assuming their suspended sediment concentration is half the Mobile River value of 48 ppm leads to order-of-magnitude estimates of 0.50 million tons suspended sediment per year into Escambia Bay and 0.08 million tons into Perdido Bay compared to 5.0 million tons for the Mobile River. Even these estimates are probably on the high side, and they must be corrected by future measurements.

The small amount of clay that the Escambia and Perdido Rivers do contribute is composed mostly of kaolinite, with smaller, but important, amounts of montmorillonite, and small amounts of vermiculite, illite, and gibbsite. An X-ray pattern of Escambia River clay (sample C37) is shown in Figure 185, and further X-ray data are listed in Appendix IV. On a regional basis, the Escambia and Perdido Rivers are intermediate in clay mineralogy between the extremely kaolinitic Apalachicola River and the less kaolinitic Mobile River. These changes in clay mineralogy are conveniently expressed as peak height ratios, using the

7.2A peak height as an indicator of kaolinite abundance and the 15A peak height as a measure of montmorillonite (± vermiculite) abundance. The resulting ratio is referred to here as the 15/7 ratio, wherein lower numbers indicate relatively more kaolinite in the clay suite. Figure 184 (from Giiffin, 1962) demonstrates the intermediate position, on a regional and clay mineral basis, of the ESCAROSA area rivers. The Perdido River 15/7 ratio of 0.4 is an estimate based on conversion of peak-area data for the river published by Parker (1968). Thus, these rivers follow the regional trend previously noted (Griffin, 1962) for the Gulf coast quite well.

The direct effect of influx of kaolinitic clays by the ESCAROSA rivers is kaolinitic clays in the upper bays. Within the bays, however, there is a marked decrease in the kaolinite content and a reciprocal increase in montmorillonite from north to south (Figure 186). This southward variation is seen best in the 15/7 ratio values, which in Escambia Bay increase from 0.84 in the lowermost Escambia River (sample C38), through values of 1.13, 1.22, 1.35, and 1.65 progressively southward (samples C39, C40, C42, and C43). The highest 15/7 ratios are in Pensacola Bay, where values of 2.23 and 2.35 were found in samples C44 and C45, culminating in a ratio of 3.21 (sample C47) immediately east of the Naval Air Station. The southward increase in 15/7 ratios ends abruptly in southern Escambia Bay and the inshore Gulf clays have much lower ratios as is discussed later.

In Santa Rosa Sound, the highest ratio known is 2.37 (sample C46) immediately west of

the Pensacola Beach bridge. To the east of the bridge, older samples taken in 1957 along the Intercoastal Waterway show a trend of ratios decreasing from 1.28 two miles east of the bridge to 1.49 twelve miles east, to 1.08 twenty-two miles east. The 1957 samples and the older stations should be resampled to measure changes that could have occurred since the first sampling. The southerly increase in 15/7 ratio in Escambia and Pensacola Bays suggest that a local source of montmorillonitic clay presently exists in the southern part of that area. Because the highest value known exists just east of the Naval Air Station, the source is probably in that immediate vicinity. This source cannot be determined positively from existing samples, however, among the most likely possibilities are: (1) dredging in Pensacola Bay; (2) effluent from some type of municipal or industrial activity. Several other possible sources, which are considered unlikely for various reasons are: (1) residual suspended sediment from the Escambia River, unlikely because the trend observed in Apalachicola Bay, which was studied in detail, results in a decrease in montmorillonite in the bay, also no trend of the Escambia Bay type is noted in Mobile Bay in an earlier reconnaissance study; (2) influx of clay from the open Gulf of Mexico, a reasonable possibility except that the ESCAROSA shelf clay is of a different type, much lower in montmorillonite, than that of Pensacola Bay; (3) erosion of bluffs along Pensacola Bay, unlikely because the clay in these bluffs, where sampled, is nearly all kaolinite, Figure 187 shows X-ray patterns of clays extracted from several bluffs overlooking Escambia and Perdido Bays--none

of the samples examined contained significant amount of montmorillonite, thus they could not contribute the montmorillonitic Pensacola Bay clay. Therefore, of the possibilities listed, only the first two seem likely, with the effects of dredging by far the most likely. Comparison of U. S. Coast and Geodetic Chart 1265 for the years 1953 and 1972 indicates that Pensacola Bay and its approaches were subjected to massive dredging and spoil disposal during that 19-year period, particularly in the vicinity of the Naval Air Station. The following projects can be noted on the charts: Caucus Channel was deepened from 32 to 37 feet for a width of 800 feet and a length of 18,000 feet; Pensacola Bay, south, southeast, and east of the Naval Air Station was dredged varying amounts to create a maneuvering area of approximately 56 million square feet with a depth of 35 feet or more. This is not to imply that the whole 56 million square feet had to be dredged, as most of the area was already, in its natural state, at least 35 feet deep. However, the dredging resulted in significant spoil, which appears, from Chart 1265, to have been placed mostly along the eastern perimeter of the Naval Air Station, essentially where the most montmorillonitic sample (C47) was taken; Pensacola Channel was dredged to a depth of 33 feet for a width of 300 feet and a length of 14,000 feet. The natural depths varied from 31 to 35 feet in this area. Spoil areas are shown on Chart 1265 paralleling both sides of the channel beginning at a distance of approximately 1500 feet; West Channel, East Channel, and the Inner Harbor Channel were deepened from previous depths of 29 to 30 feet to new depths of 33 feet. The

new width is 300 to 500 feet for a total length of approximately 18,250 feet. Spoil areas are indicated in the central part of Pensacola Bay. Therefore, all of the ESCAROSA samples in which montmorillonite was relatively enriched, with a 15/7 ratio greater than 2.0, were taken from the highly dredged area of Pensacola Bay between Pensacola Bay bridge, the Pensacola Beach bridge, and the Naval Air Station. It appears likely that the dredging, by cutting downward into materials that are different from those exposed on the bluffs around the bay, may have increased the introduction of montmorillonite into the lower bay. However, because the natural channels were in places as deep, or even deeper than the dredge channels, it is likely that the montmorillonite enrichment was occurring, probably to a lesser extent, even prior to the dredging. It is still speculative, of course, that beds of more montmorillonitic clay exist below the bay bottom at sub-sea level depths of 35 feet or so. No cores were examined in the present project, and we can only infer from published cross-sections and previous clay mineral analyses in other parts of the northern Gulf coast. It has been shown by Musgrove, et al (1965) that Miocene clays dip westerly or southwesterly beneath the ESCAROSA area. The depths of 200-300 feet which they indicate, if accurate, suggest that the clays would <u>not</u> have been penetrated by Pensacola Bay dredging. However, their cross-sections show the upper surface of the Miocene clays as irregular; and in fact, the upper surface of the clay rises about 400 feet beneath Pensacola Bay. Although it cannot be demonstrated by the data at hand, the possibility exists that the upper surface of the Miocene

clays, or less extensive strata of similar type, might be present at a shallower depth below Pensacola Bay than indicated. Elsewhere along the northern Gulf coast, sub-surface Miocene clays are often highly montmorillonitic, and their erosion would be quite capable of yielding the type of clay seen in Pensacola Bay. Even the younger formations of the area, the Pleistocene age sediments, are often very montmorillonitic when seen in well samples. It is mainly in outcrops or near-surface samples, subjected to intense subaerial weathering, that the materials are extremely kaolinitic as in the samples from the bluffs around the ESCAROSA bays. Shallow well samples, such as Musgrove, et al (1965) examined lighologically, contain numerous shallow, intermittent clay stringers that could possibly yield the type of clay seen in Pensacola Bay. Of course, the mineralogy of the well samples would have to be examined to confirm this hypothesis.

As indicated schematically in Figure 186, the ESCAROSA inner shelf clay differs from the clay of Pensacola Bay and appears related to a different sedimentological regime with different causative factors. The inner shelf clay is moderately kaolinitic and is derived in part from the Apalachicola River via littoral drift (Figure 184). During its 100-mile longshore journey to the ESCAROSA area, the Apalachicola clay, which originally had a 15/7A ratio near 0.3 (as in the Indian Peninsula Beach sample), has become somewhat diluted by mixing with clays from the larger, more montmorillonitic central Gulf rivers. The resulting mixed clay off ESCAROSA has a 15/7A ratio in the 0.9 to 1.9 range. All of the contributors

to the mixing cannot be identified quantitatively; however, the ESCAROSA inner shelf clay with an 0.9 to 1.9 ratio could be produced artificially by mixing 50 to 80 percent Mississippi River clay with 50 to 20 percent Apalachicola River clay. West of the Mobile Bay entrance, the inner shelf and littoral clay (e.g. at Dauphin Island Beach) resembles the Mobile River and Bay clay; both have 15/7A ratios near 0.8. Some of this Mobile River clay could have drifted eastward and contributed to the ESCAROSA inner shelf. The contribution, however, was probably small as the main littoral drift direction is westward. In any event, it is not distinctly different from a mixture of Apalachicola and Mississippi Rivers clay; thus, it cannot be specifically detected or mapped.

Farther offshore, on the outer part of the traverse including samples 61 to 65, the clay becomes more montmorillonitic. Relying on past experience with regional clay distribution in the area (Griffin, 1962, Figure 184), this outer shelf clay is assigned predominantly to a Mississippi River origin. Samples 64 and 65, in particular, with 15/7A ratios averaging 3.0 or greater (Appendix IV) are quite similar to Mississippi River clay, which also has a ratio averaging near 3.0. Most of the Mississippi River clay is, in fact, deflected toward the west as part of the general littoral and offshore drift. However, as indicated by Scruton (1956) and in Table XVII, approximately 25-35 percent does move eastward across the outer shelf and into deeper waters, principally during periods of winds from the west. The influence of this Mississippi clay on the eastern Gulf offshore region

is quite marked (Figures 183 and 184). It should be especially noted that there is extremely little clay on the ESCAROSA shelf. Parker (1968) noted that the concentration of clay on the shelf between Perdido and Pensacola Bays averaged 0.16 percent, with a reported range of 0.00 to 1.10 percent. Although clay percentages were not determined as part of the present project, the clay content on the shelf was observed to be qualitatively very small. In fact, in quite a few samples sufficient clay for X-ray analysis (less than 0.5 gram) could not be extracted from the small samples supplied. The clay content is, of course, considerably higher in the bays. Parker (1968) reported an average clay content exceeding 12 percent, and the Escambia-Pensacola Bay samples are equally muddy. These samples produced excellent clay patterns in contrast to the poor patterns of many of the shelf sediments.

CONCLUSIONS

1. It has been demonstrated that at least for the time period of the investigation the characteristics of the territorial sea waters adjacent to ESCAROSA were influenced by the quality of the waters flowing from Mobile Bay and/or the Mississippi River delta; superimposed upon these effects from the west were contributions from the Perdido and Escambia river systems. These contributions appeared both within the surface and bottom waters. It was found that the waters flowing into the study area from the west were generally enriched in both trace metals and pesticides, with certain exceptions. These exceptions relate to the presence of well-defined eddies of trace metals and pesticides in both the

surface and bottom waters southwest of the Perdido and Escambia River systems. The distribution and location of these eddies is apparently due to tidal action.

2. Although measurable quantities of the pesticides DDT, DDE, TDE, Dieldrin and Heptachlor epoxide were generally present in the study area, Aldrin and Endrin were measured only in trace and non-detectable amounts respectively. The polychlorinated biphenyls (PCB's) were detected in an area generally to the east and west of the Perdido River. Concentrations of the pesticides found in this study are significant. A report from the Department of Interior (1966) has shown that less than 1 ppb of DDT will kill blue crabs, that brown and pink shrimp exposed to 0.3-0.4 ppb of Heptachlor, Endrin or Lindane were either killed or immobilized, and that in water containing 10 ppt of DDT oysters concentrated this pesticide 70 thousand times over a 40-day period. When three species of unicellular algae were exposed to one ppm of DDT, they concentrated this pesticide from 99 to 964 times. Although the concentration of pesticides might be low in the water, the phytoplankton will nevertheless remove it. Food chains can thus concentrate pesticides from the aquatic environment to provide man with relatively high concentrations in his food.

3. The Florida territorial sea of the ESCAROSA region is characterized by very fine to coarse sands, with the majority of the sediment in the fine-to-medium sand range, with two major exceptions: (1) an area of very fine sand nearshore in the westernmost

measured section near Mobile Bay, coincident with a significantly higher organic sediment content than that measured in the remaining offshore region; and, (2) an area of fine sand surrounded by medium to coarse sands approximately in the middle of the measured offshore section and slightly to the east of the mouth of Pensacola Bay.

4. An offshore area characterized by relatively high sediment trace metal concentrations was documented within a well-defined upwelling region, coincident with the fine-sand area described above.
5. The ESCAROSA bay area measured in this study is characterized by sediments in the fine-sand to mud range. The bays act as fine-sediment traps, effectively blocking the runoff to offshore of much of the silt and clay size material introduced into them from the surrounding land area. High concentrations of trace metals are coincident with the distribution of these silt and clay size materials.
6. The bay areas are characterized by relatively high organic sediment values. In Escambia Bay, a higher percentage of organic materials occurs in the upper bay as opposed to the lower bay region, indicating a considerably greater degree of flushing action by water movement within the lower bay.
7. Relative carbonate concentration values show a western minimum with a marked increase to the east. A well-defined, high-carbonate region exists from two to five miles offshore beginning near the mouth of the bay system and paralleling the shoreline to the

extreme eastern boundary of the studied area.

8. An evaluation of the relationships between sigma t values, trace element distribution patterns, sediment grain-size distribution, and percent organics indicates a characteristic interrelationship for this region, and is documented for the first time in this report.

9. Interpretation of the available sedimentary data strongly suggests a general eastward water movement, from a presumed origin in the Mobile Bay or Mississippi Delta areas, leading to the conclusion that these westerly derived waters have a far greater influence on the distribution of the measured sedimentary and geological variables in this study than does runoff from the ESCAROSA area.

10. The Perdido and Escambia Rivers both contribute richly kaolinitic clays to their respective bays. Kaolinite decreases south, with a relative increase in montmorillonite. This trend is considerably stronger in the Escambia-Pensacola Bay system than in Perdido Bay. A montmorillonitic maximum is reached in an intensely dredged area immediately east of the Pensacola Naval Air Station. This is theorized as being an artifice of dredging activity. In Perdido Bay, the montmorillonitic maximum occurs near Inerarity Point, where it is much less pronounced than the Pensacola Bay maximum.

11. On the ESCAROSA Inner Continental Shelf, the clays are significantly different from the montmorillonitic types of Pensacola Bay and appear to be related to a different type of

sedimentary regime, more regional in nature. The inshore clays are moderately kaolinitic and are related to the westerly drift of sediment in the littoral zone along the northwest Florida-Alabama coasts. The source is partly to the east, and these clays represent a much diluted remnant of the richly kaolinitic Apalachicola River influx. The clay becomes progressively more montmorillonitic toward the west, and in the extreme western part of the ESCAROSA shelf in the deeper part of the westernmost sample traverse, the clay suite is related to the regional dispersal pattern of clay in the eastern Gulf. Here, in the deeper water samples, the clay suite has become diluted by the montmorillonitic Mississippi River-derived clay suite, which during times of west winds is carried to the outer shelf and deeper parts of the eastern Gulf.

12. The relatively small amount of clay contributed by the Escambia and Perdido Rivers allows their contributions to be diluted and effectively masked by influx from other sources. Masking is evident in Escambia and Pensacola Bays, where the clay in the lower bay bears essentially no resemblance to Escambia River clay. It is important to note that relatively small amounts of artificial contaminants can have a significant pollutional effect on a clay-deficient environment of this type.

13. The ESCAROSA area bays appear to be isolated, from a clay mineralogical standpoint, from the adjacent inner shelf. It seems that essentially all of the fine-grained inorganic detritus that finds its way into the Escambia-Pensacola Bay system will be

deposited within that system. Flushing of clay from the bay into the Gulf seems negligible, and the bay system must assimilate the bulk of its own particulate debris.

14. The offshore sediments, with few exceptions, were characterized by relatively low and uniform trace metal concentrations. The exceptions were an area approximately 3½ miles south of the entrance to Pensacola Bay, and several inshore areas to the west of the entrance. The sediments at these sites were slightly enriched in tin, lead, nickel, copper and manganese. The sediments within the bay systems generally contained higher concentrations of all trace metals. The sediments in the upper regions of the bay systems contained higher concentrations of trace metals than were found in the lower reaches. Here they were at or near the same level as those found in territorial sea waters. These high concentrations measured in the upper bay regions tend to indicate that the materials entering the water column of the bay system are settling out before they reach the territorial sea waters.

15. This interdisciplinary approach to the problems of ESCAROSA has demonstrated that the quality of the territorial sea sediments is primarily affected by factors outside the ESCAROSA bay system. It is important, therefore, to recognize that from a sedimentary point of view there is a major management problem existing within the bay system. There appears to be little if any interrelation between the sedimentary regime within the bay system and the territorial sea area.

16. The major measured effects in the Florida territorial sea off ESCAROSA are the result of a major influence outside the study area, and to the west. There is good evidence to conclude that this area is Mobile Bay. The results of analyses from investigations of the trace element distribution, pesticide distribution, sedimentary parameters and wind and water dynamics all independently lead to this conclusion. Additionally, it is shown that the effects of the input of Escambia and Pensacola Bays into the territorial sea are minimal, and that the major portion of the pollutant loads of the rivers and runoff entering these bays is contained within them.

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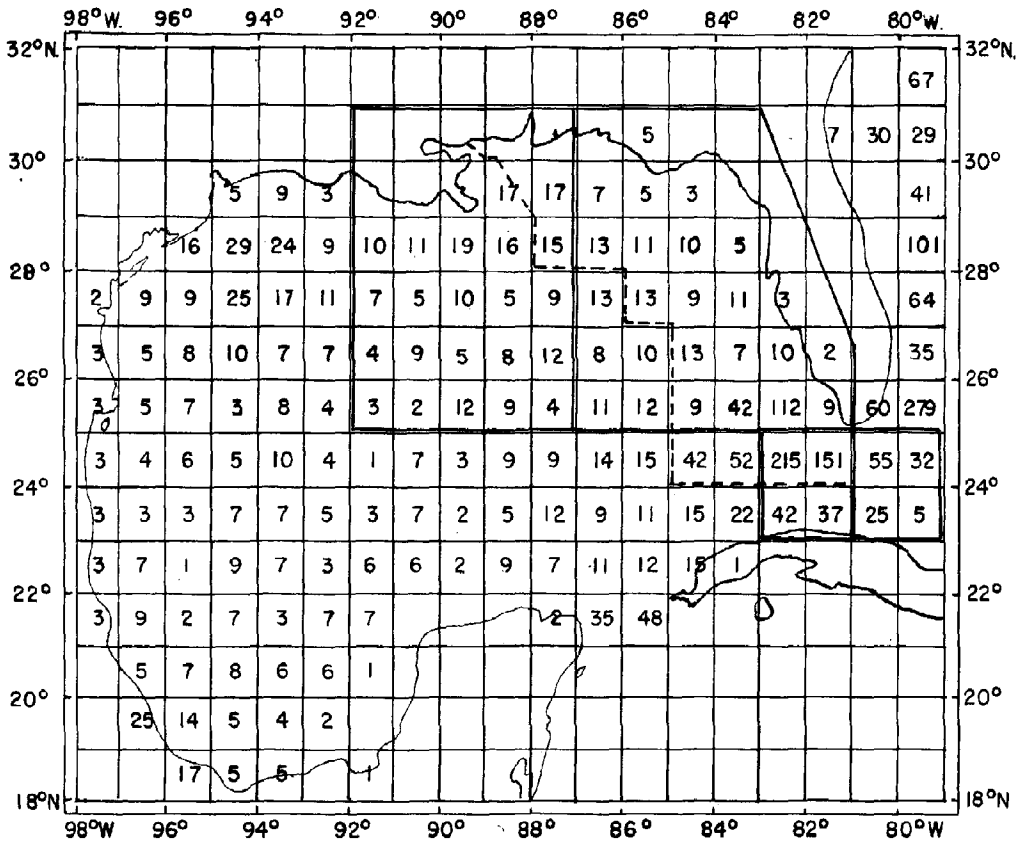


Figure 1. Number of Oceanographic Station Casts at NODC as of 1970.

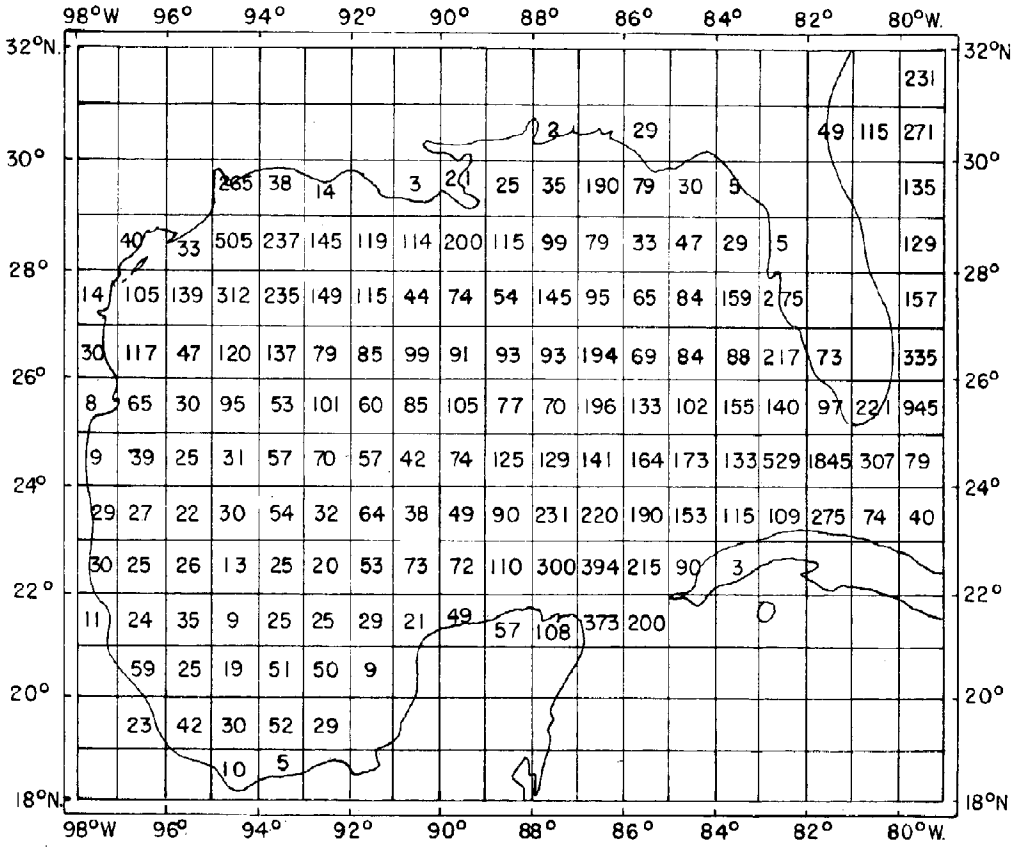


Figure 2. Number of MBT/Marsden Squares at NODC as of 1970.

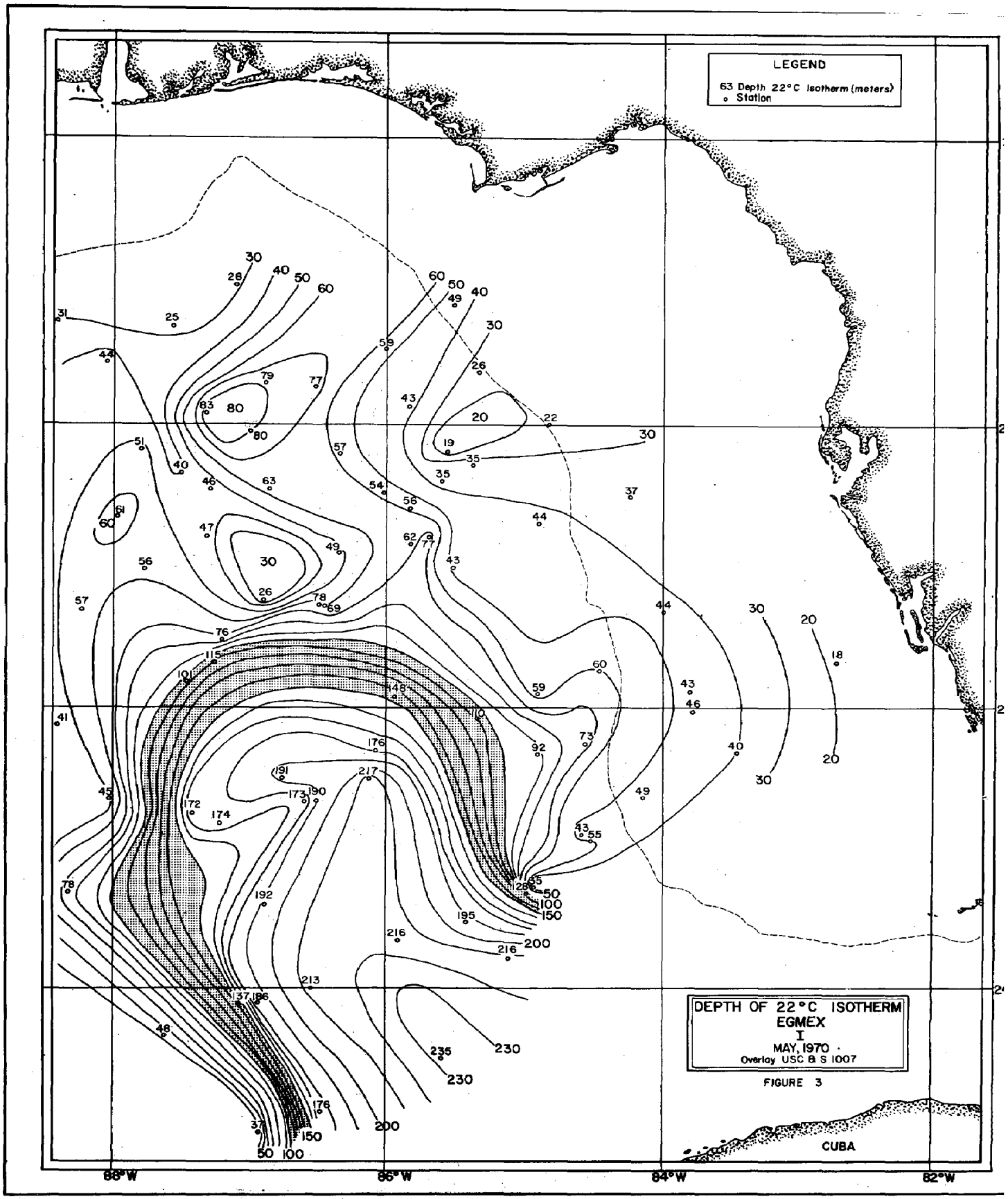

LEGEND
63 Depth 22°C Isotherm (meters)
Station
DEPTH OF 22°C ISOTHERM
EGMEX
I
MAY, 1970
Overlay USC & S 1007
CUBA
88°W
86°W
84°W
82°W

FIGURE 3

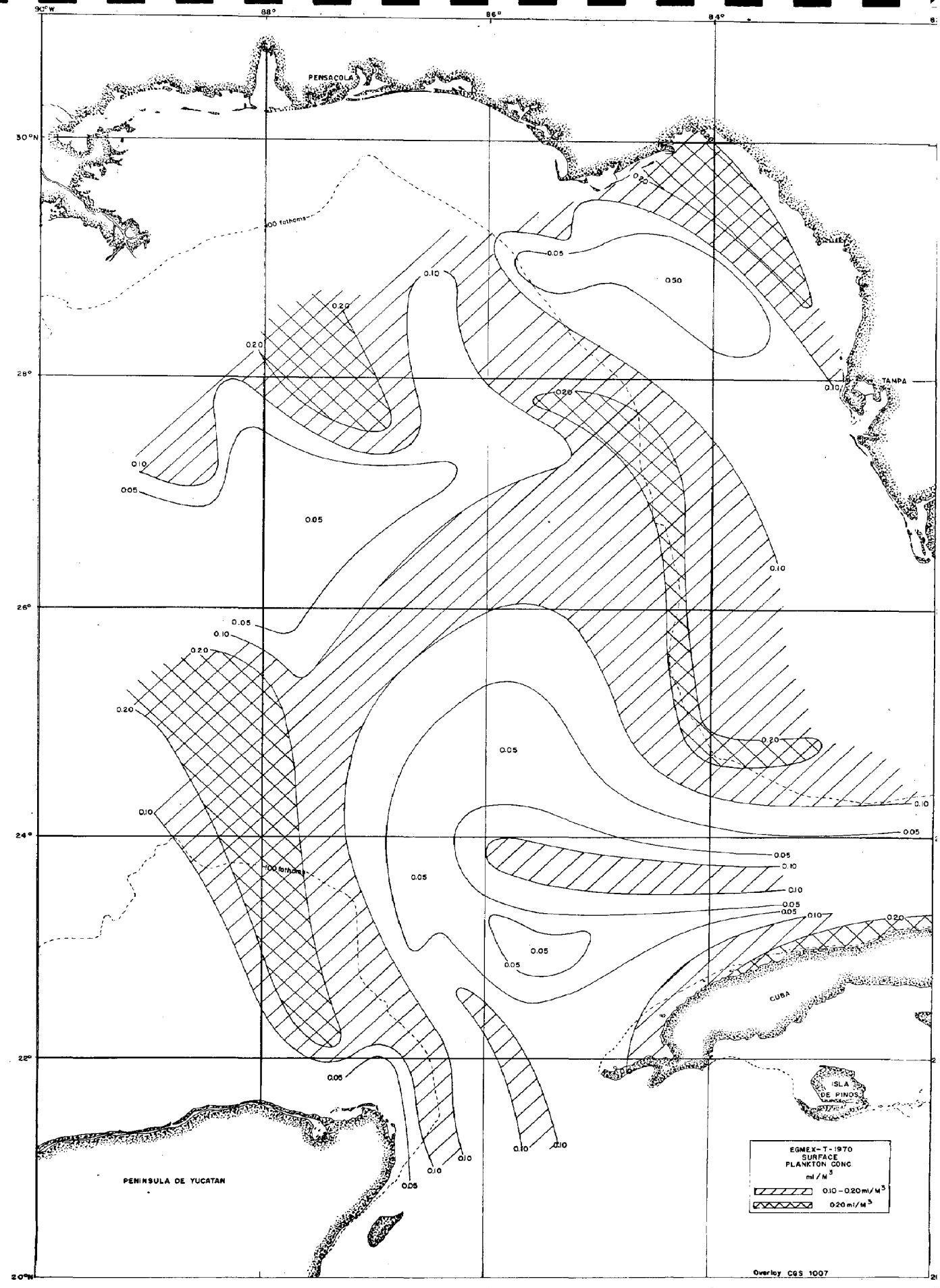


Figure 4. Surface distribution of biomass measured in milliliters of plankton per cubic meter of water for May 1970 (from Austin, 1971 and based on EGMEX-I)

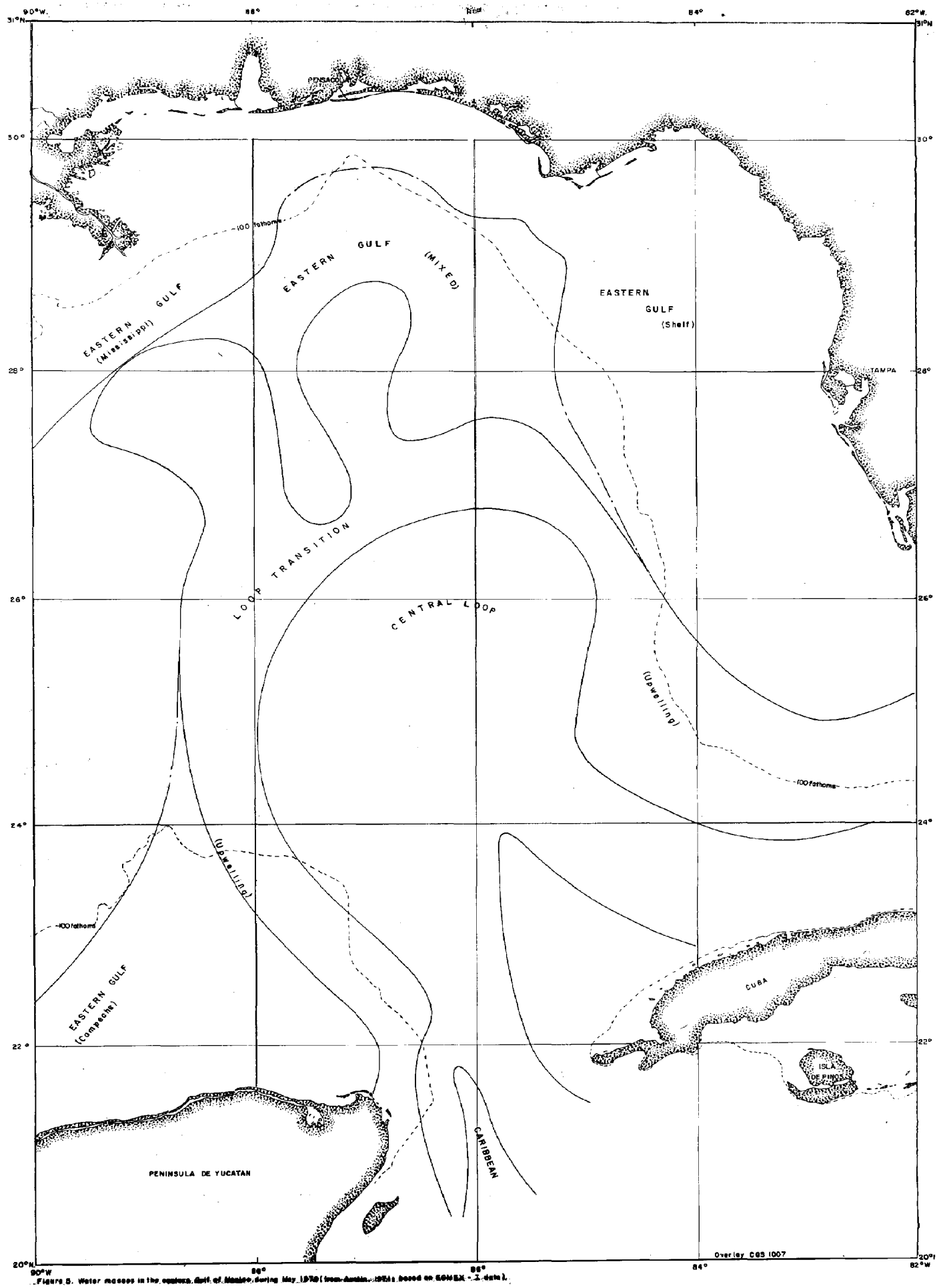


Figure 5. Water masses in the eastern Gulf of Mexico during May 1970 (from Austin, 1971a based on EGMEX - 1 data).

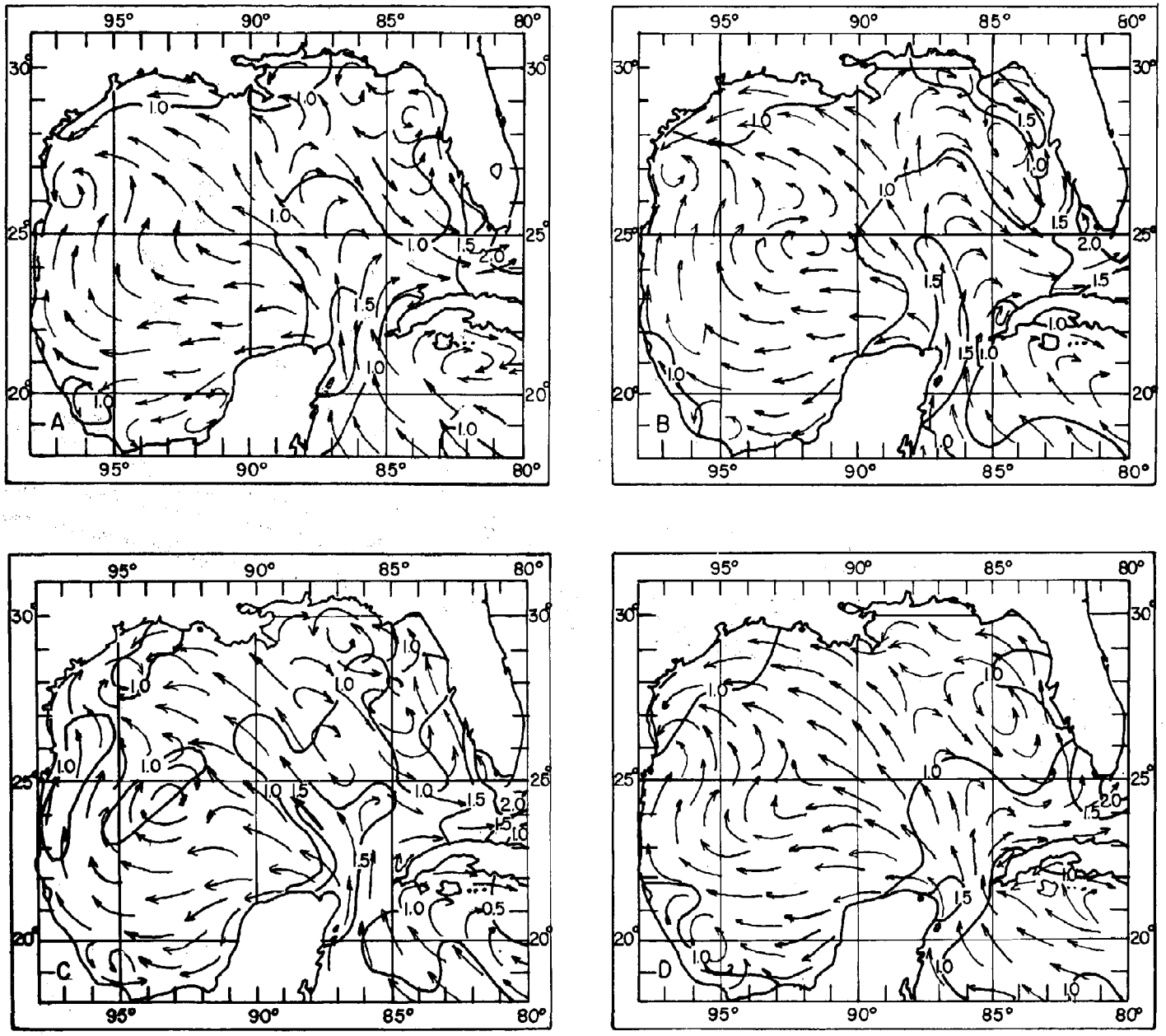


FIGURE 6. PREVAILING SURFACE CURRENT PATTERNS - A. WINTER (JAN.-MAR) B. SPRING (APR.-JUN.) C. SUMMER (JUL.-SEP.) D. FALL (OCT.-DEC.) ⟶ PREVAILING CURRENT ISOTACHS WERE CONSTRUCTED FROM MEAN SPEED (KNOTS) TABULATED FROM DATA BY 1° QUADRANGLES. FROM ENVIRONMENTAL-ACOUSTICS ATLAS-AUGUST, 1972 - U.S. NAVAL OCEANOGRAPHIC OFFICE.

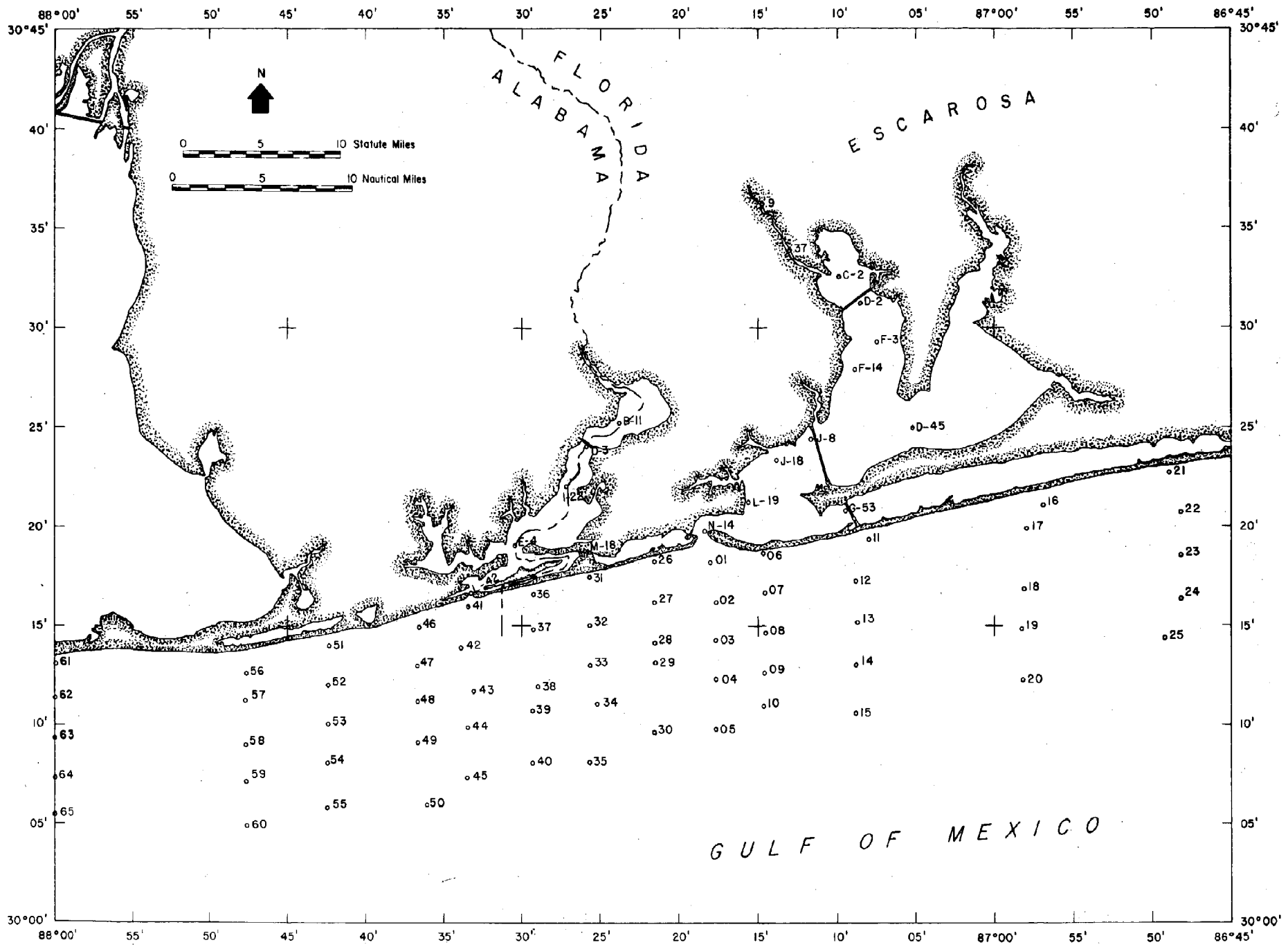


Figure 7 Station Locations and Station Numbers ESCAROSA I

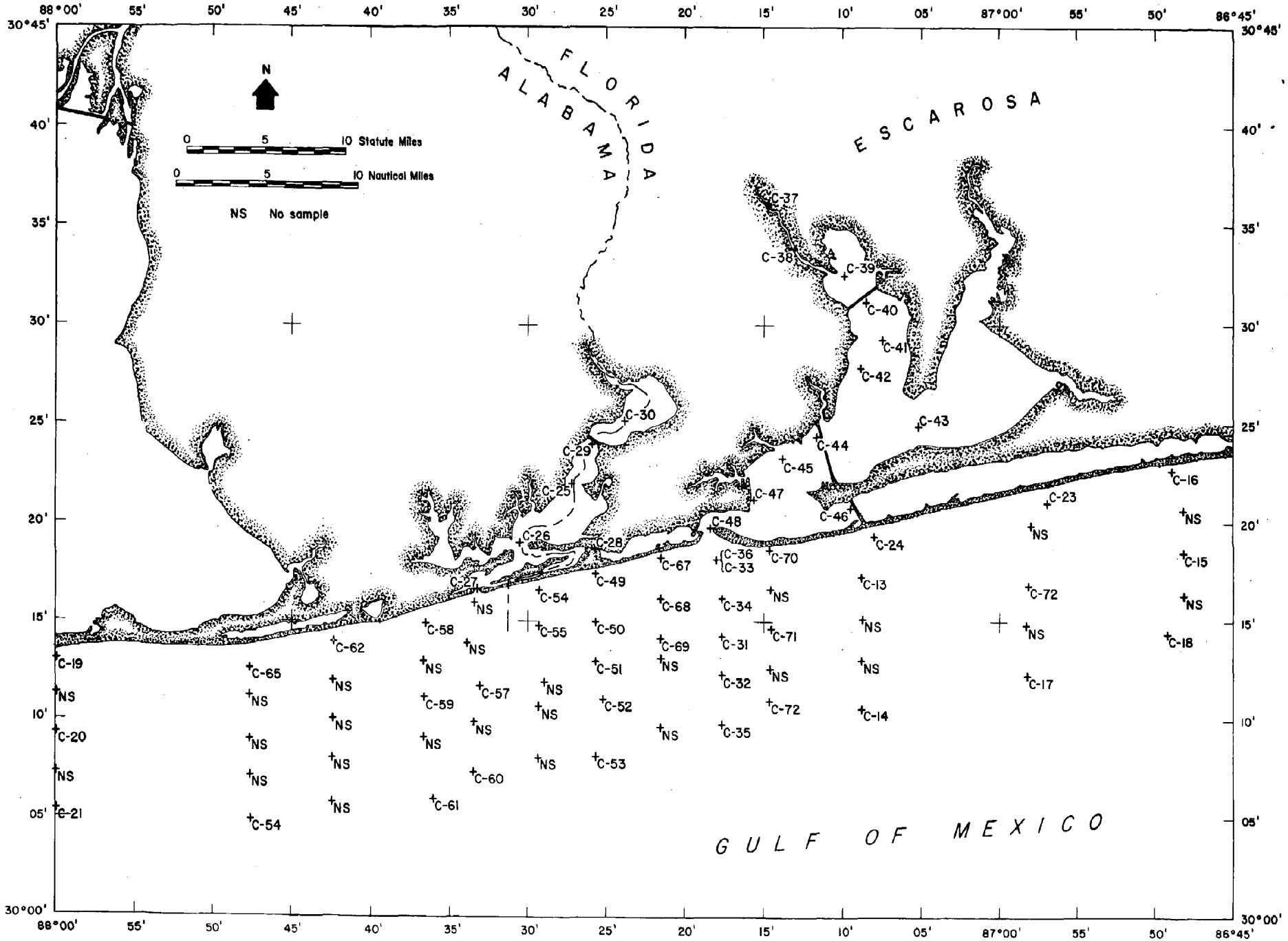
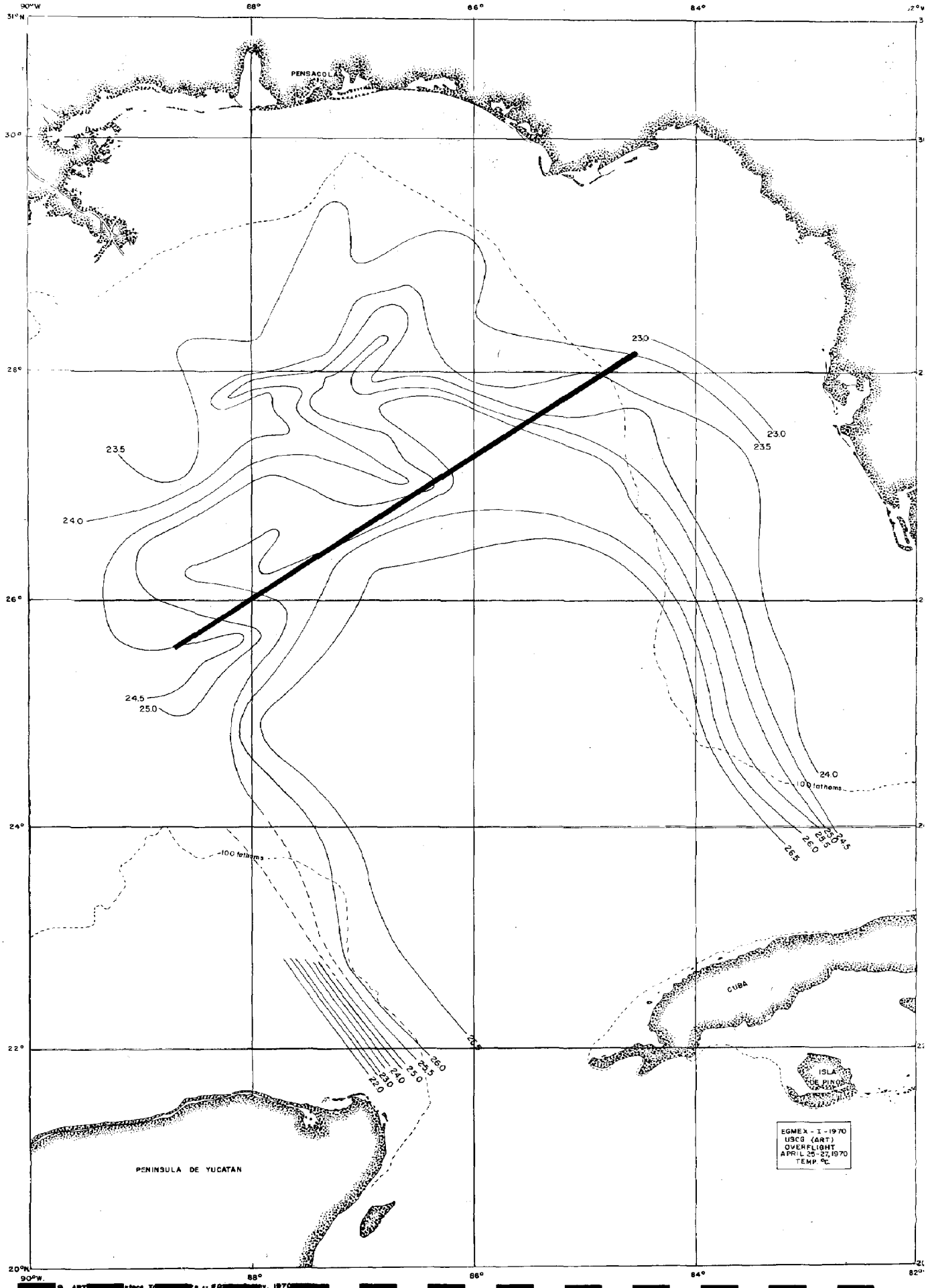


Figure 8 Station Location and Sample Numbers of Ekman Dredges


90°W
88°
86°
84°
31° N
30°
28°
26°
24°
22°
20° N
PENSACOLA
23.0
23.5
24.0
24.5
25.0
100 fathoms
26.0
26.5
CUBA
ISLA DE PINOS
PENINSULA DE YUCATAN
EGMEX - I - 1970
USCG (ART)
OVERFLIGHT
APRIL 25-27, 1970
TEMP. °C

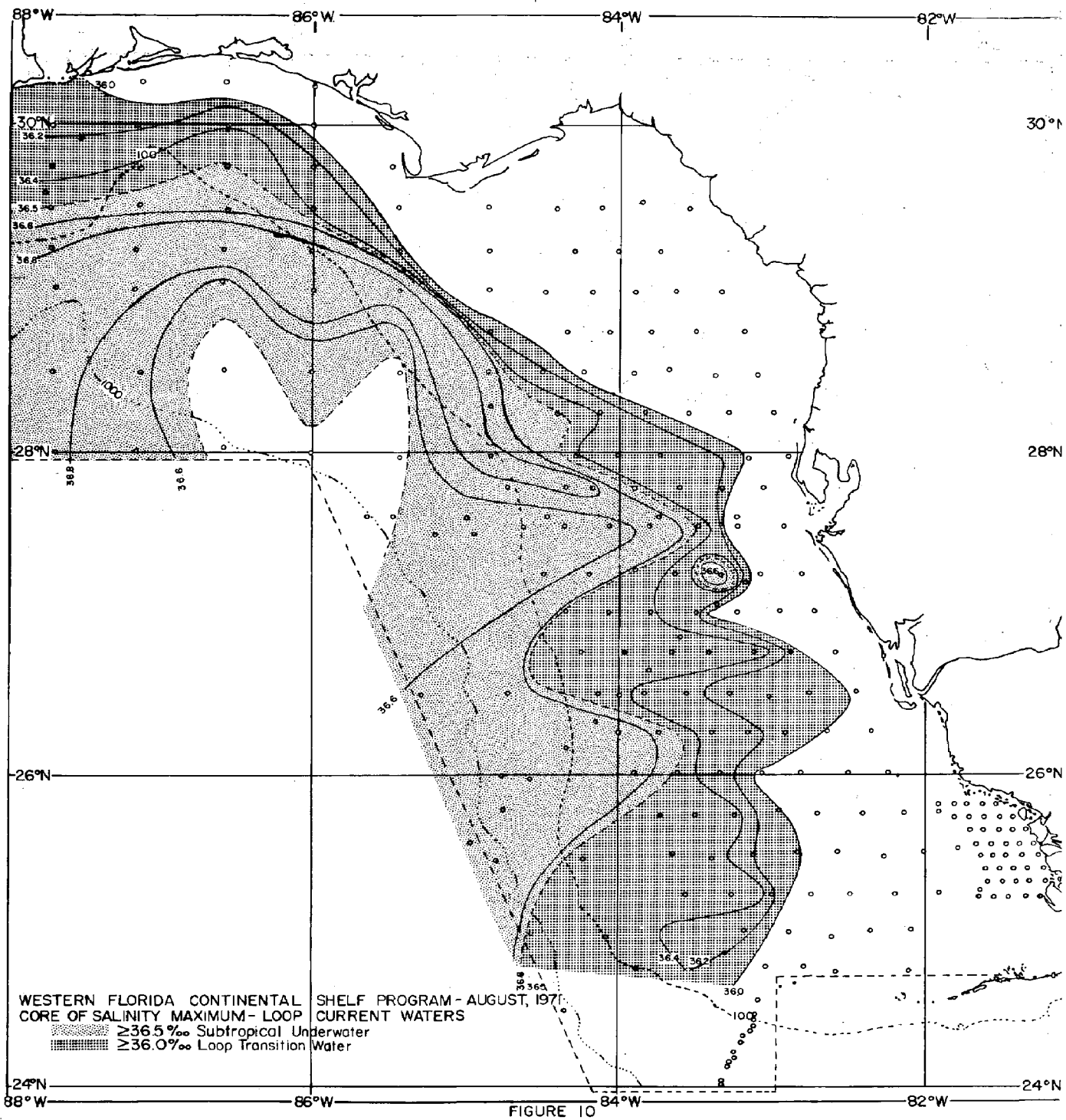

88°W
86°W
84°W
82°W
30°N
28°N
26°N
24°N
WESTERN FLORIDA CONTINENTAL SHELF PROGRAM - AUGUST, 1971
CORE OF SALINITY MAXIMUM - LOOP CURRENT WATERS
≥36.5‰ Subtropical Underwater
≥36.0‰ Loop Transition Water

FIGURE 10

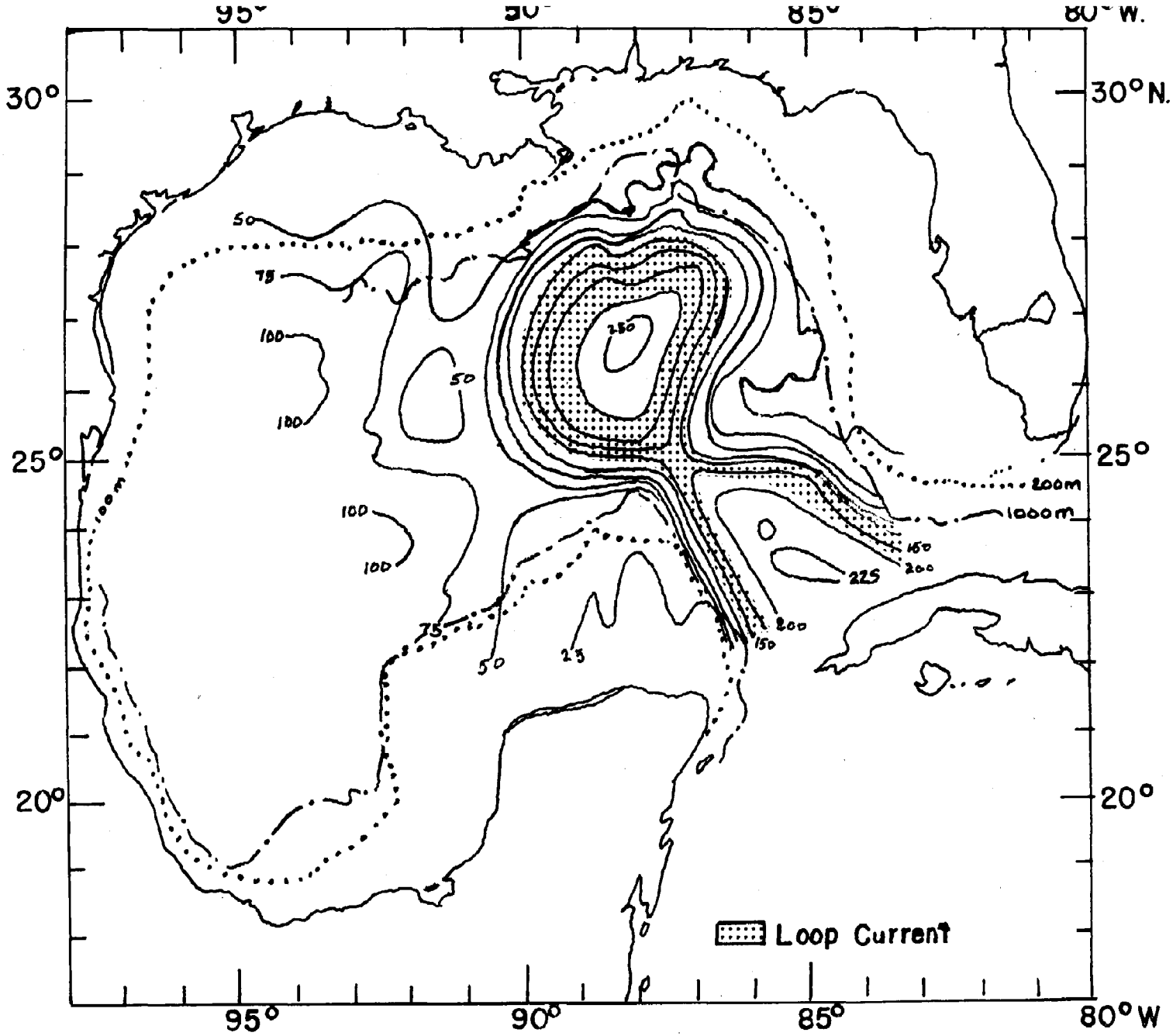


FIGURE 11 Topography of the 22° isotherm surface August 4-18, 1966 ALAMINOS 66-A-11 (From Leipper 1970).

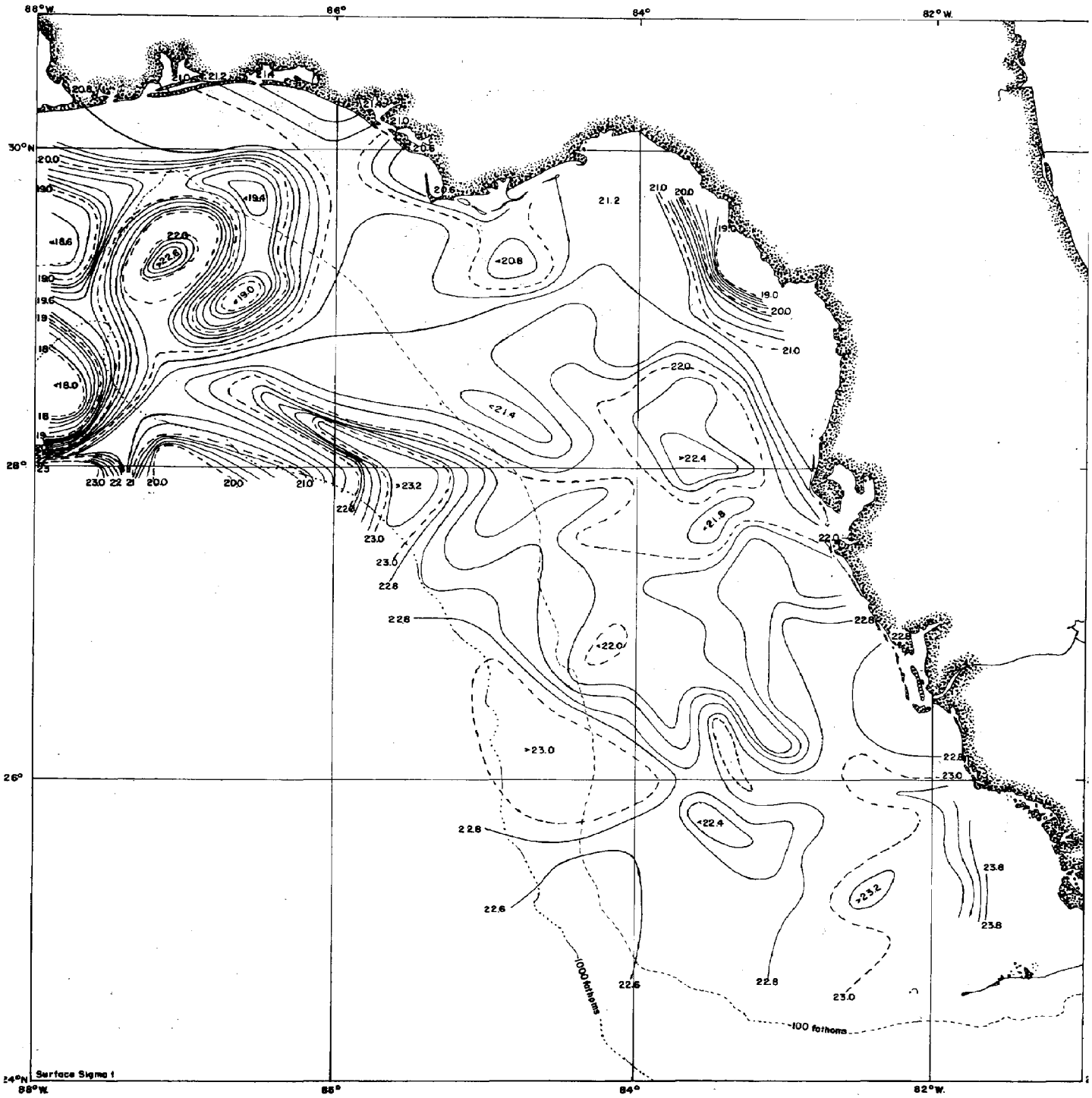


Figure 12 Surface Sigma t - EGMEX IV, August, 1971

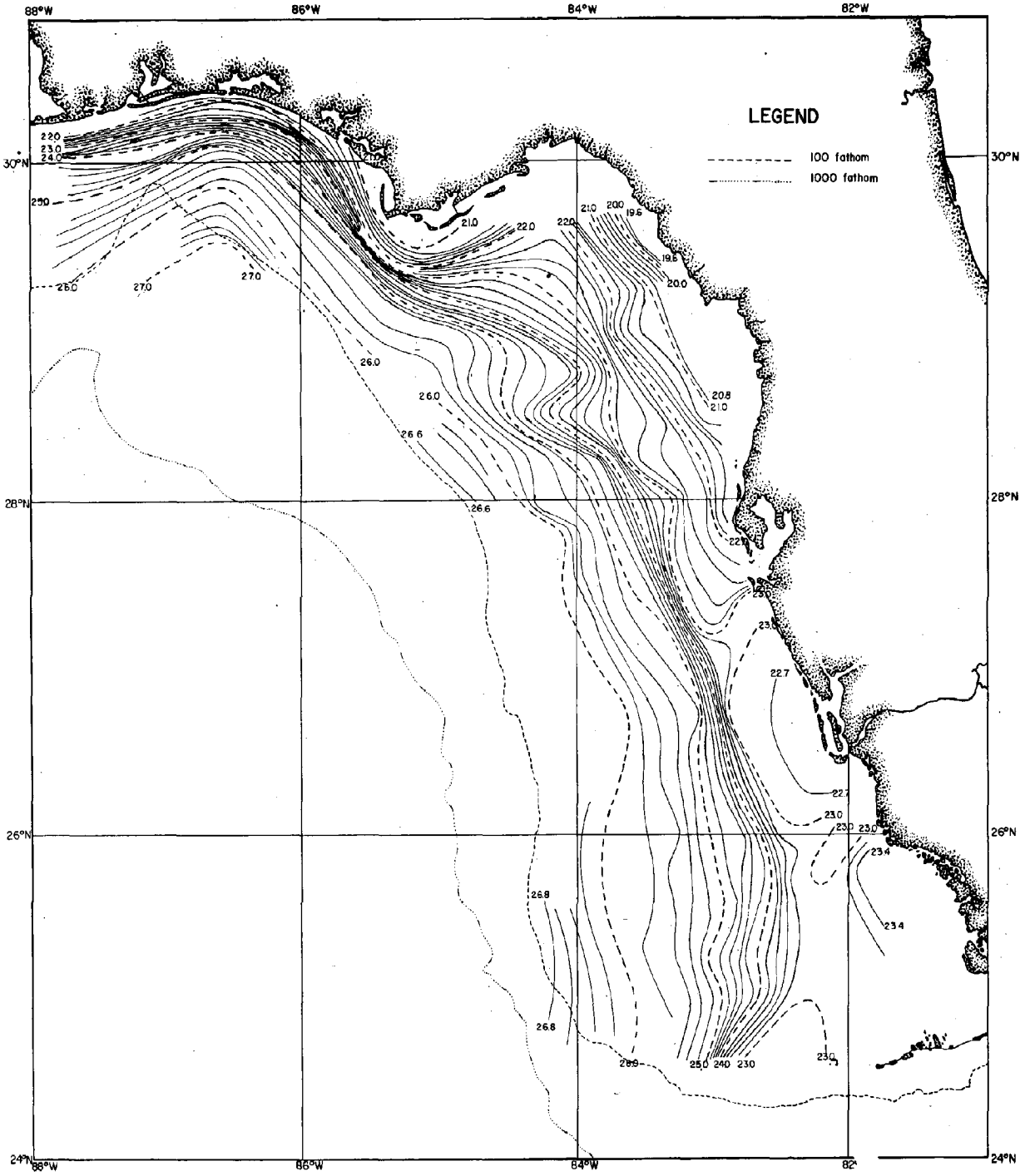


Figure 13 Bottom Sigma t - EGMEX IV, August, 1971

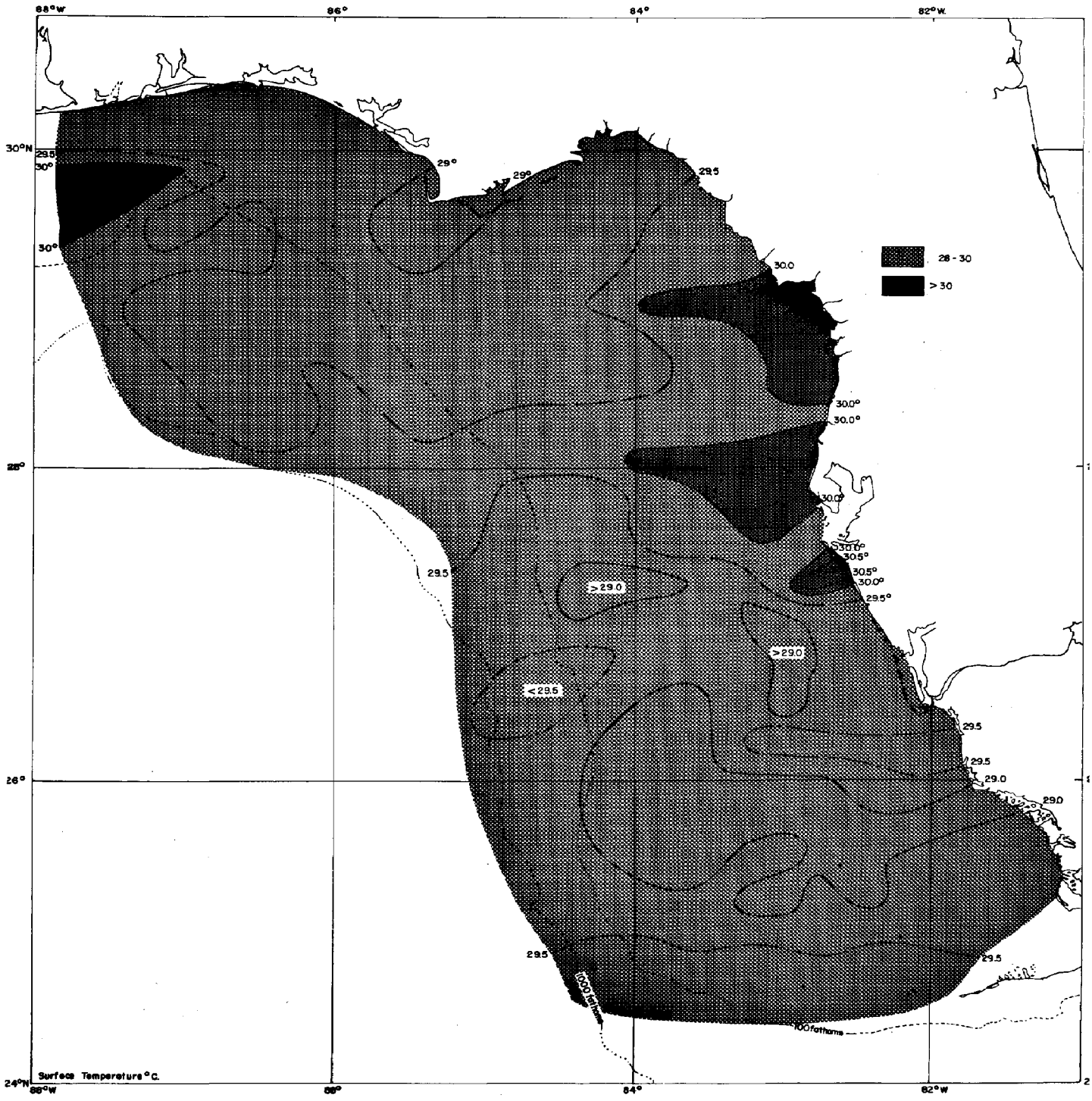


Figure 14 Surface Temperature - EGMEX IV, August, 1971

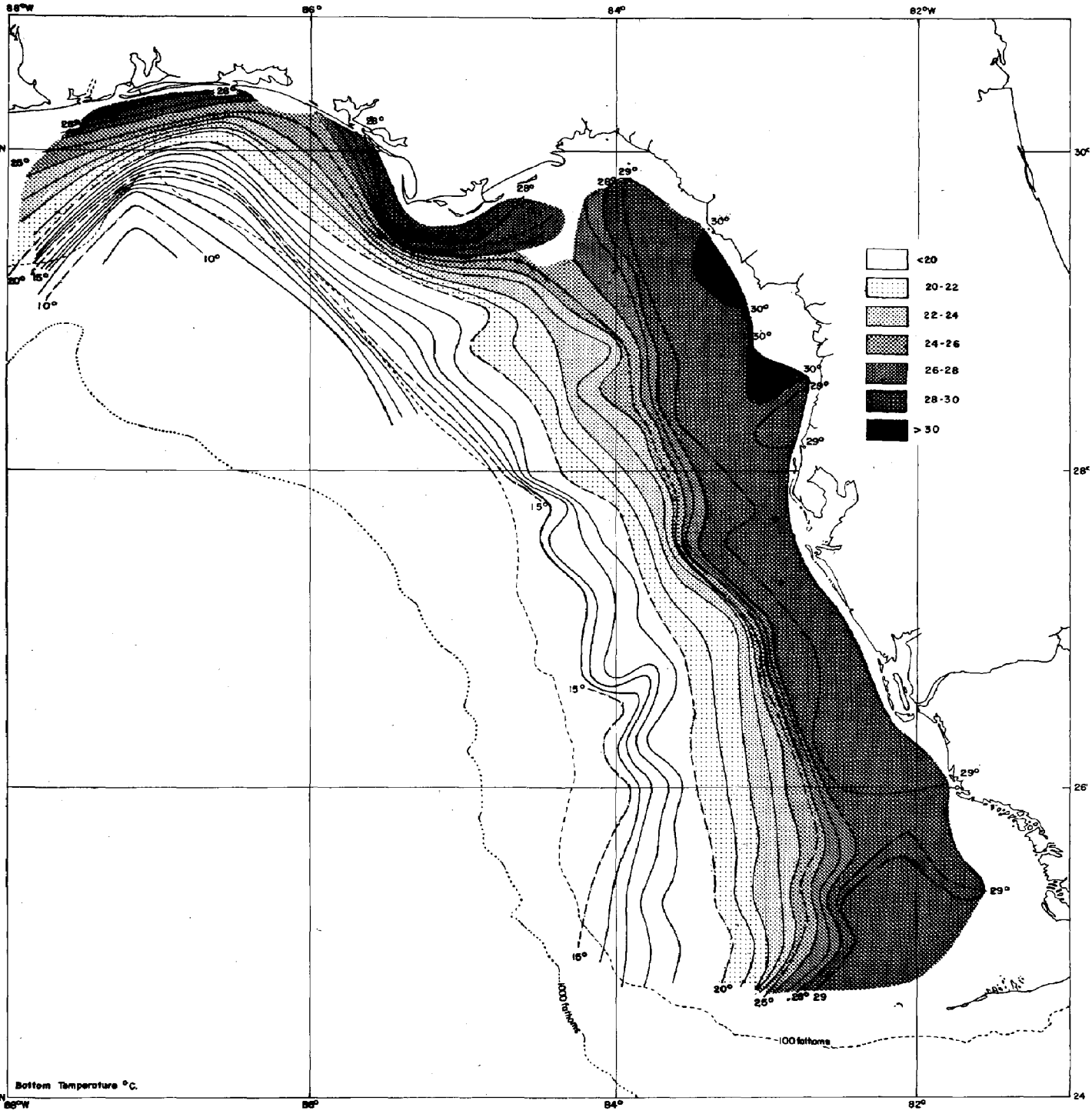


Figure 15 Bottom Temperature - BGMEX IV - August, 1971

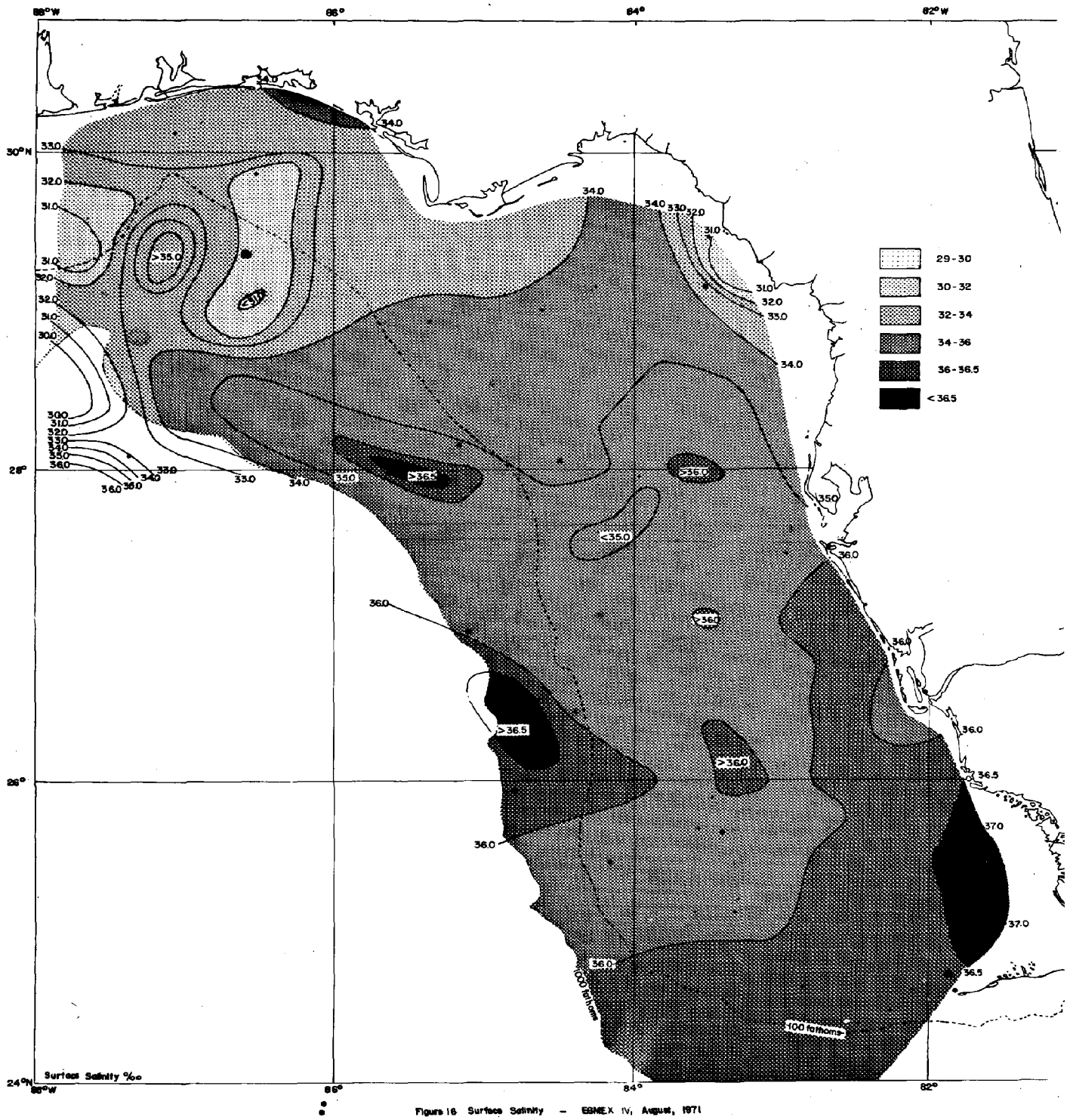


Figure 16 Surface Salinity – EBMEX IV, August, 1971

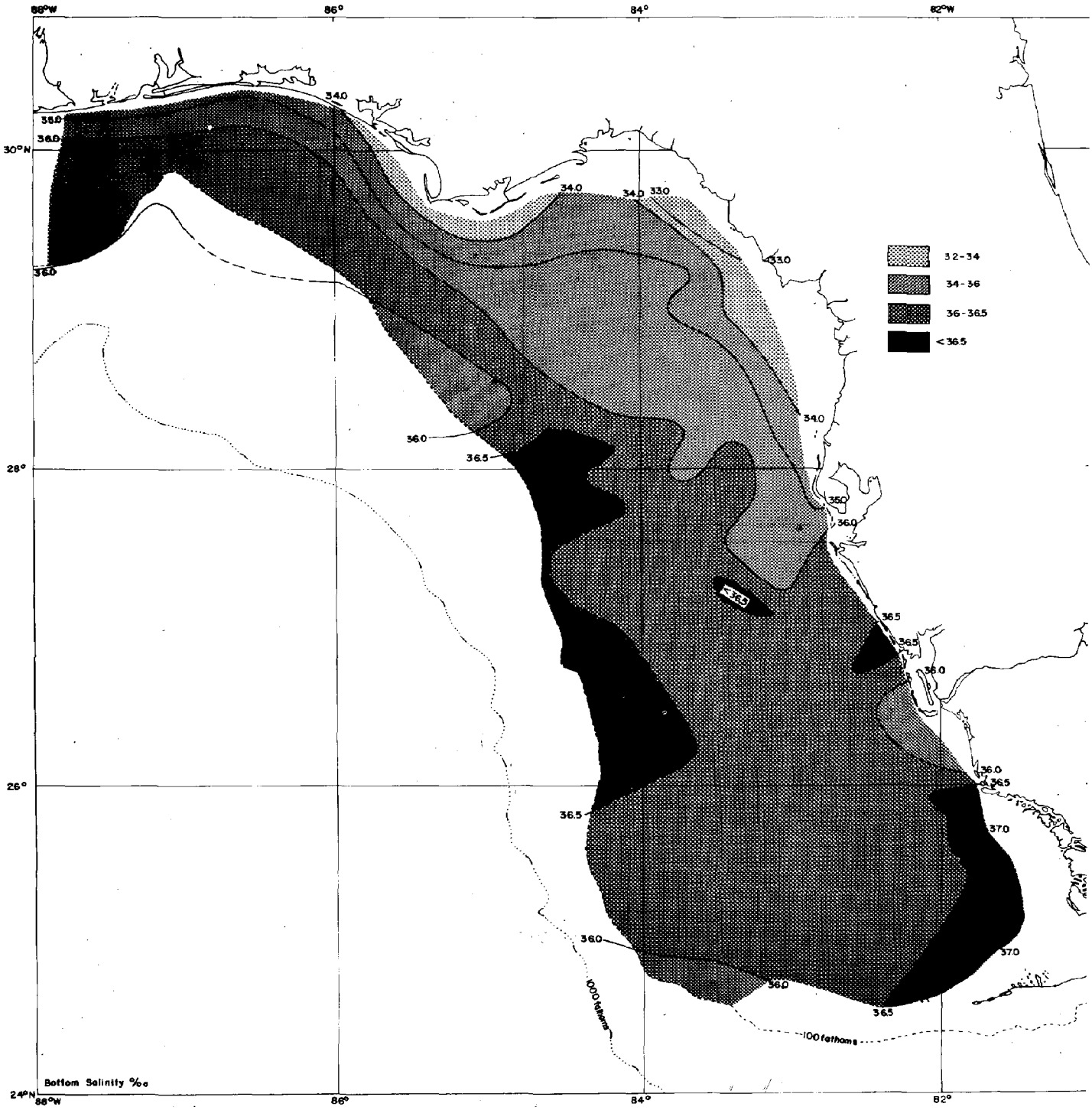
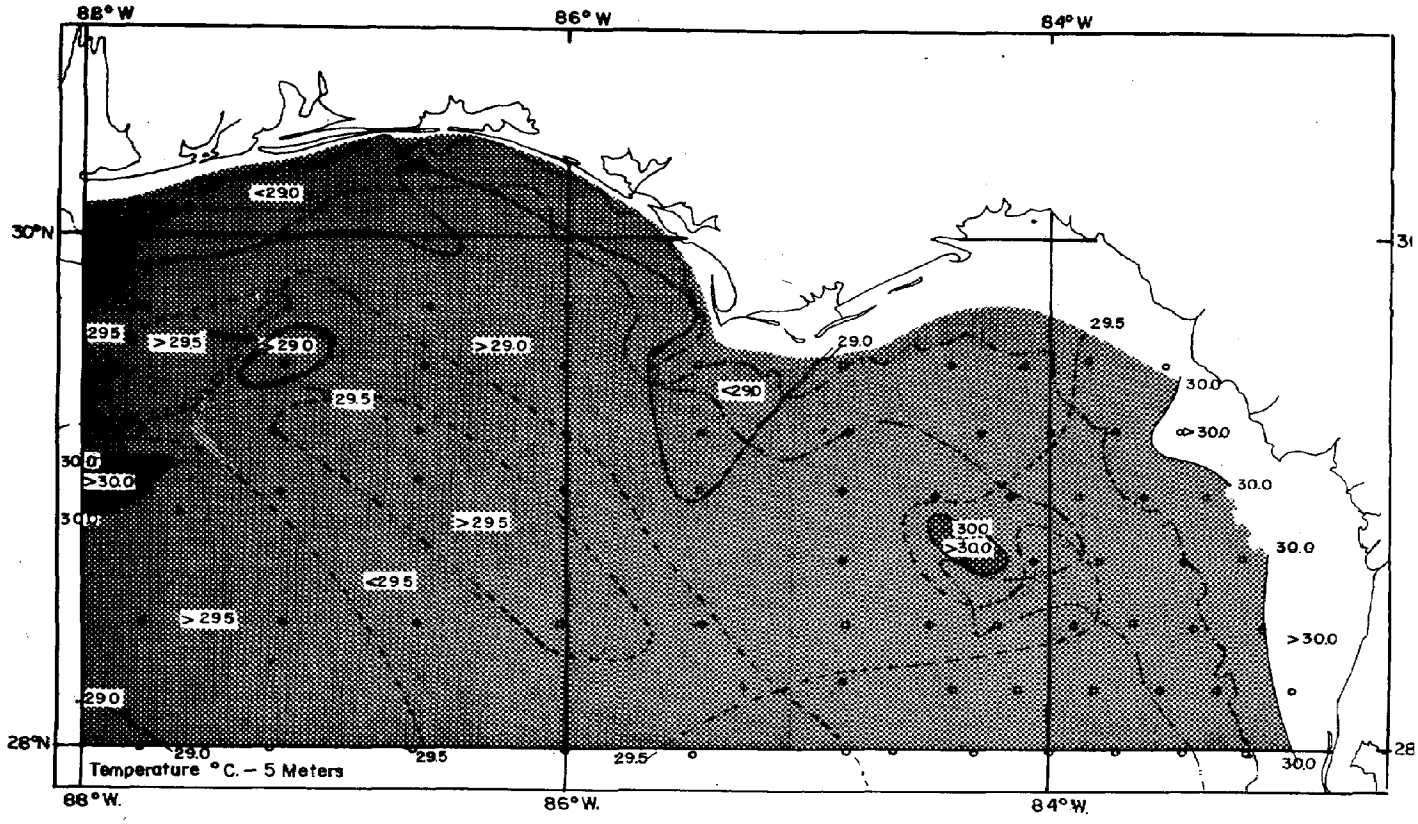


Figure 17 Bottom Salinity – EGMEX IV, August, 1971



≤ 30 | 28 to 30 | 26 to 28 | 24 to 26

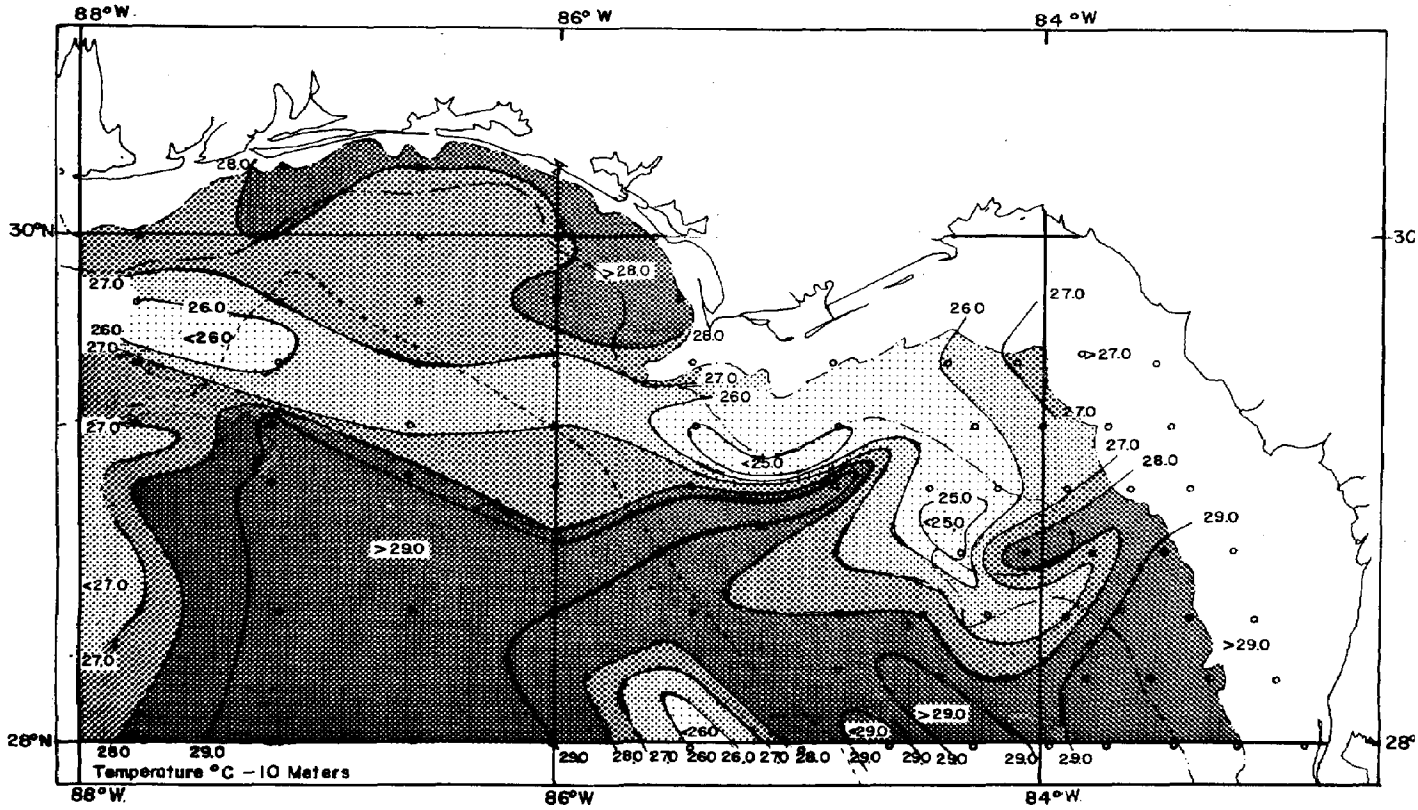
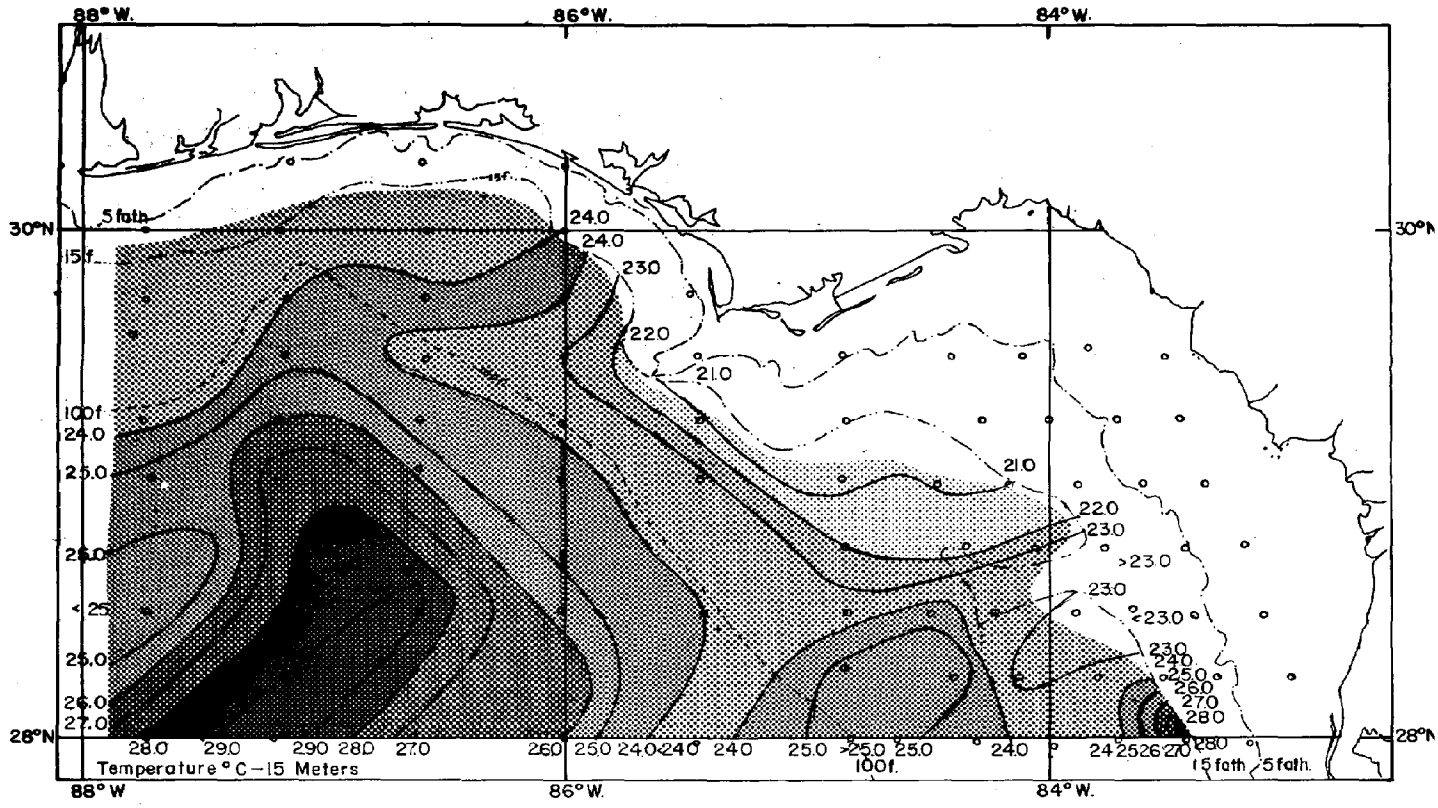


Figure 18 Temperature Distribution at Standard Depths at 5 and 10 Meters – EGMEX IV – August, 1971



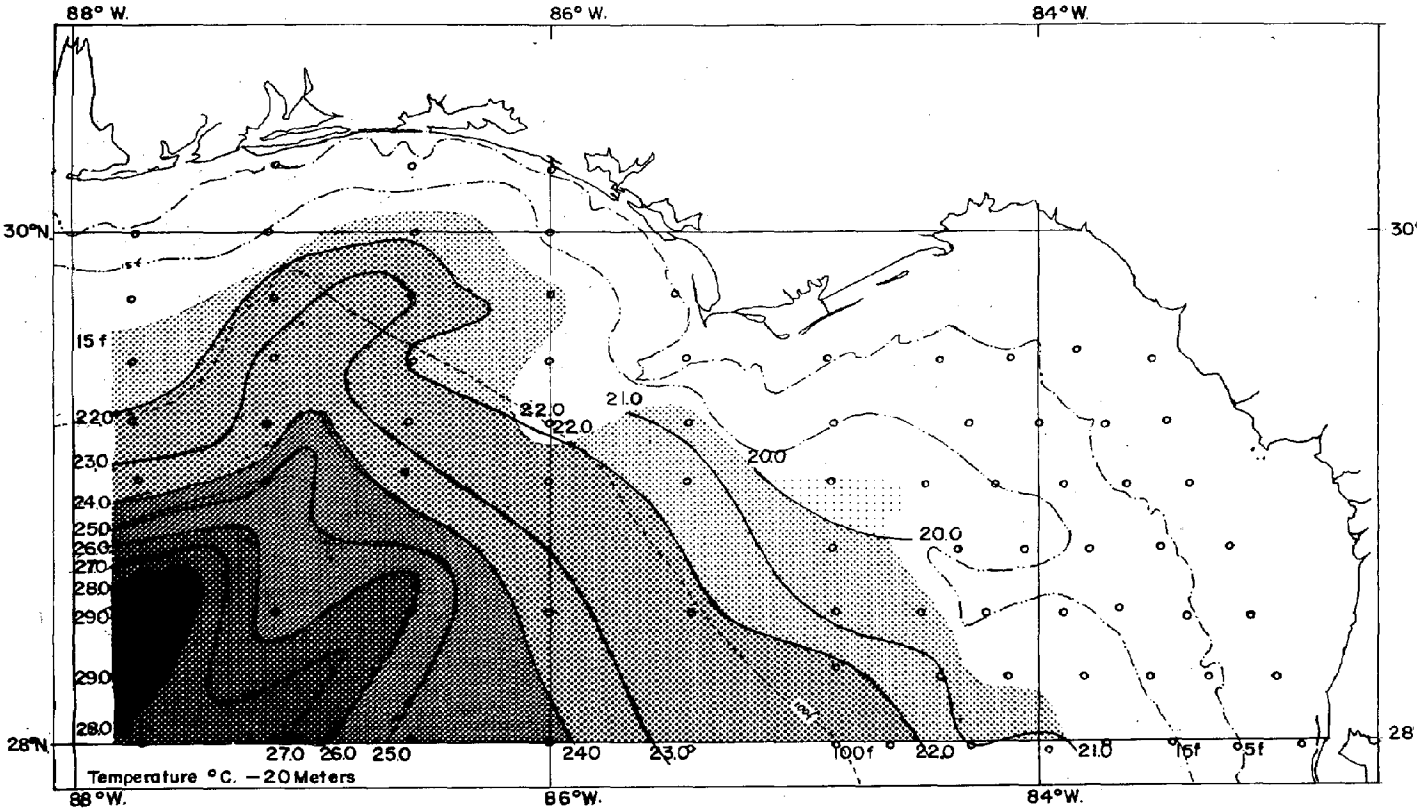
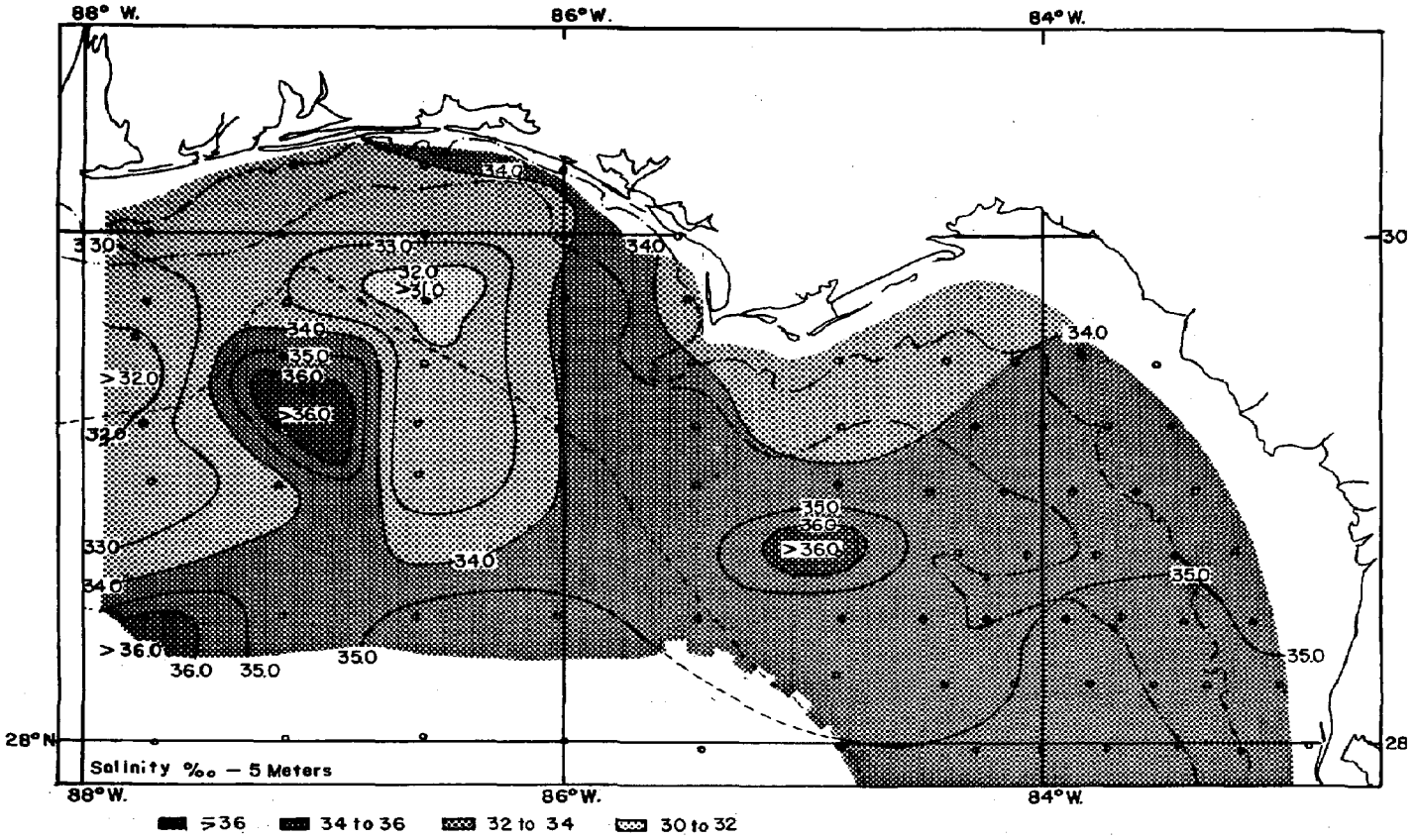


Figure 19 Temperature Distribution at Standard Depths of 15 and 20 Meters – EGMEX IV – August, 1971



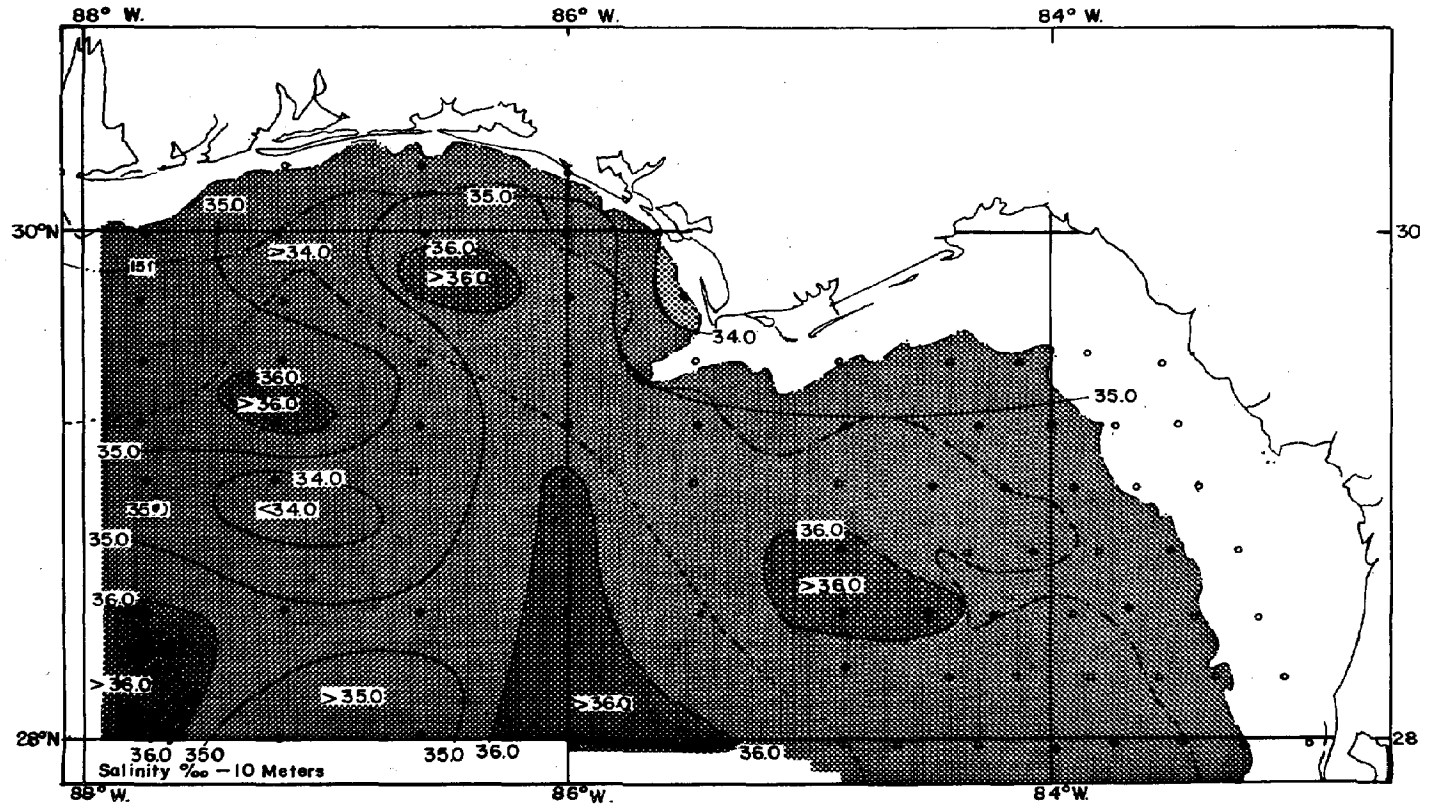
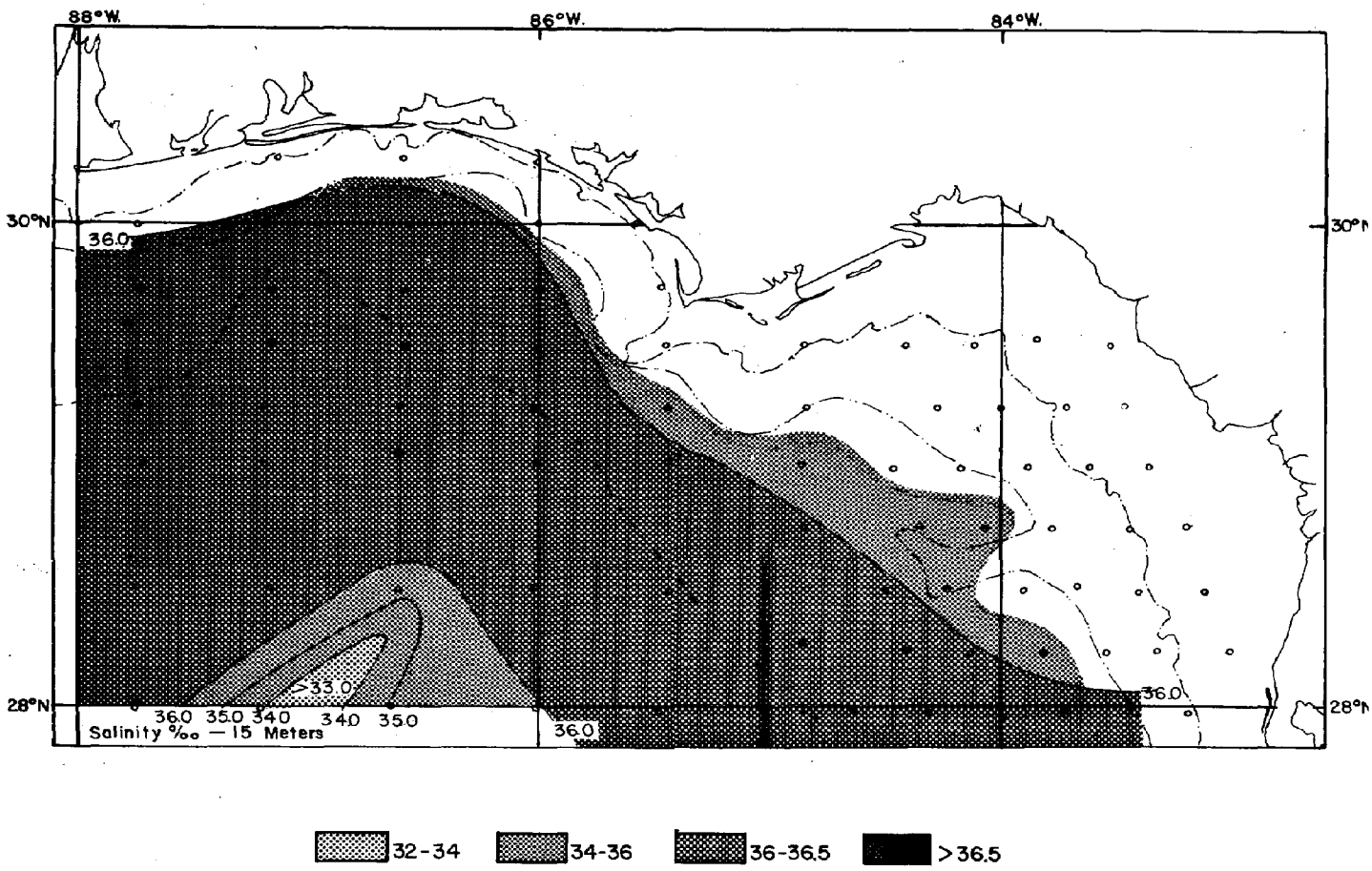


Figure 20 Salinity Distribution at Standard Depths of 5 and 10 Meters — EGMEX IV - August, 1971



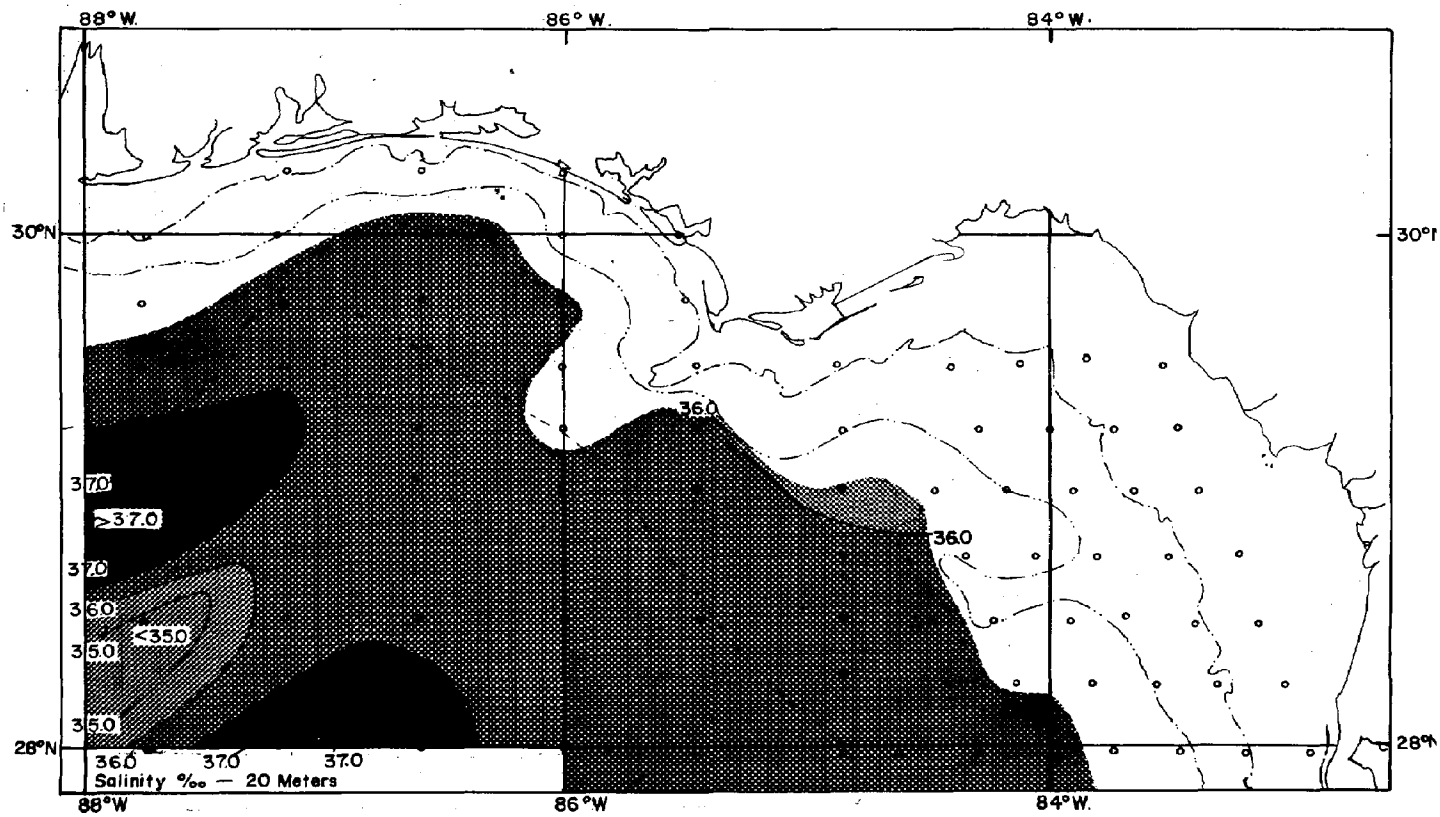


Figure 21 Salinity Distribution at Standard Depths of 15 and 20 Meters – EGMEX IV August, 1971

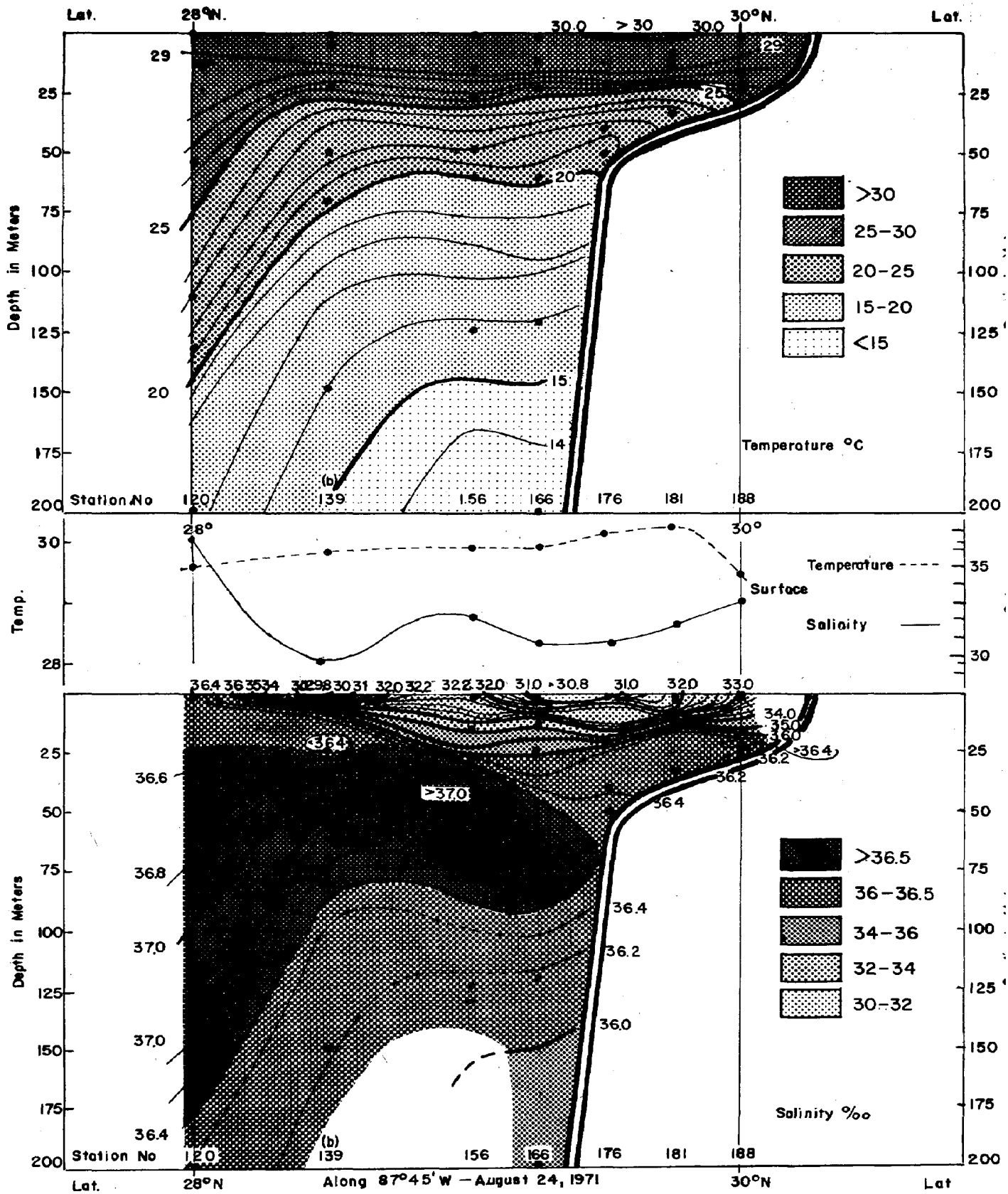


Figure 22 Vertical Distribution Temperature and Salinity - EGMEX - IV

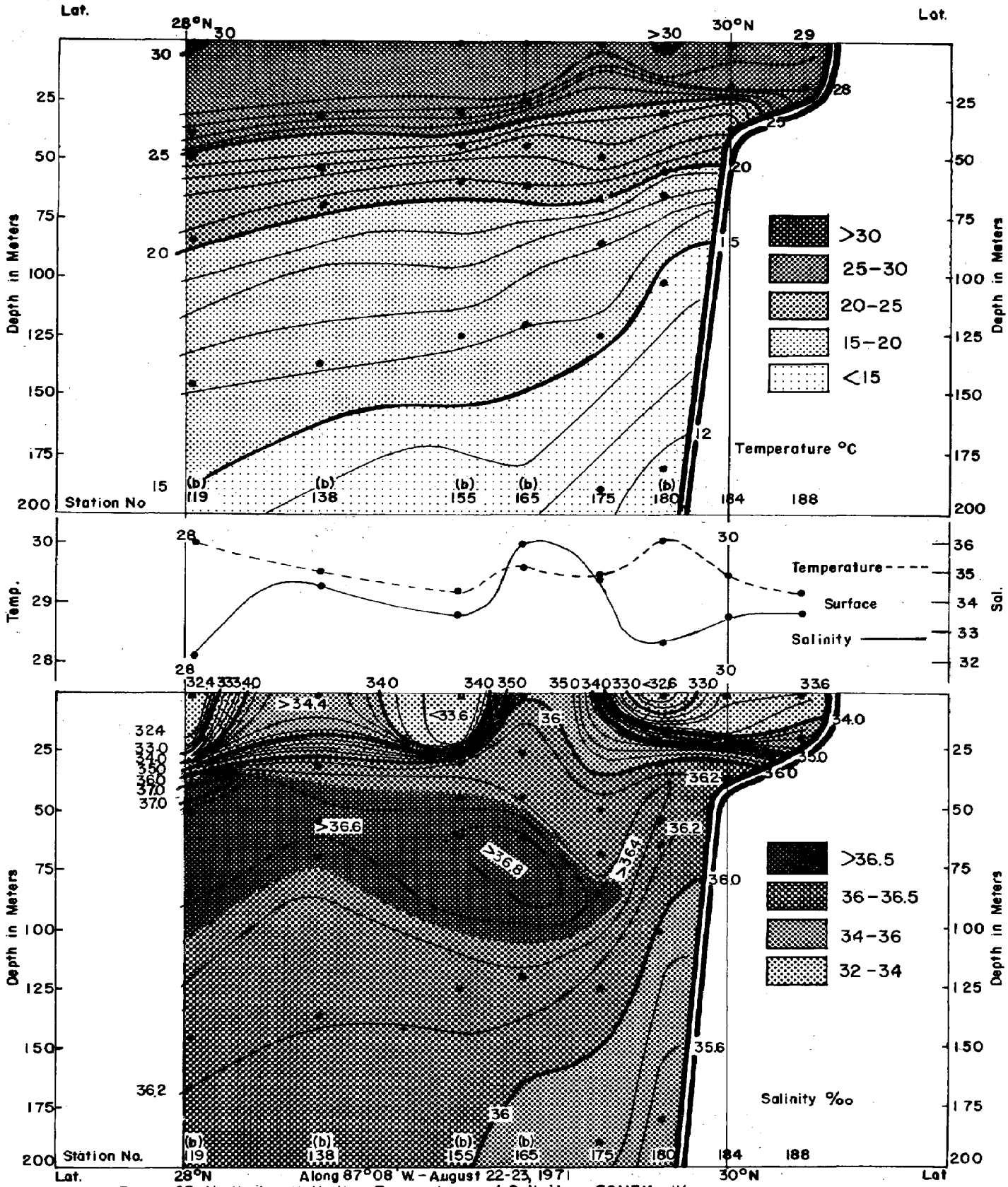


Figure 23 Vertical Distribution Temperature and Salinity - EGMEX - IV

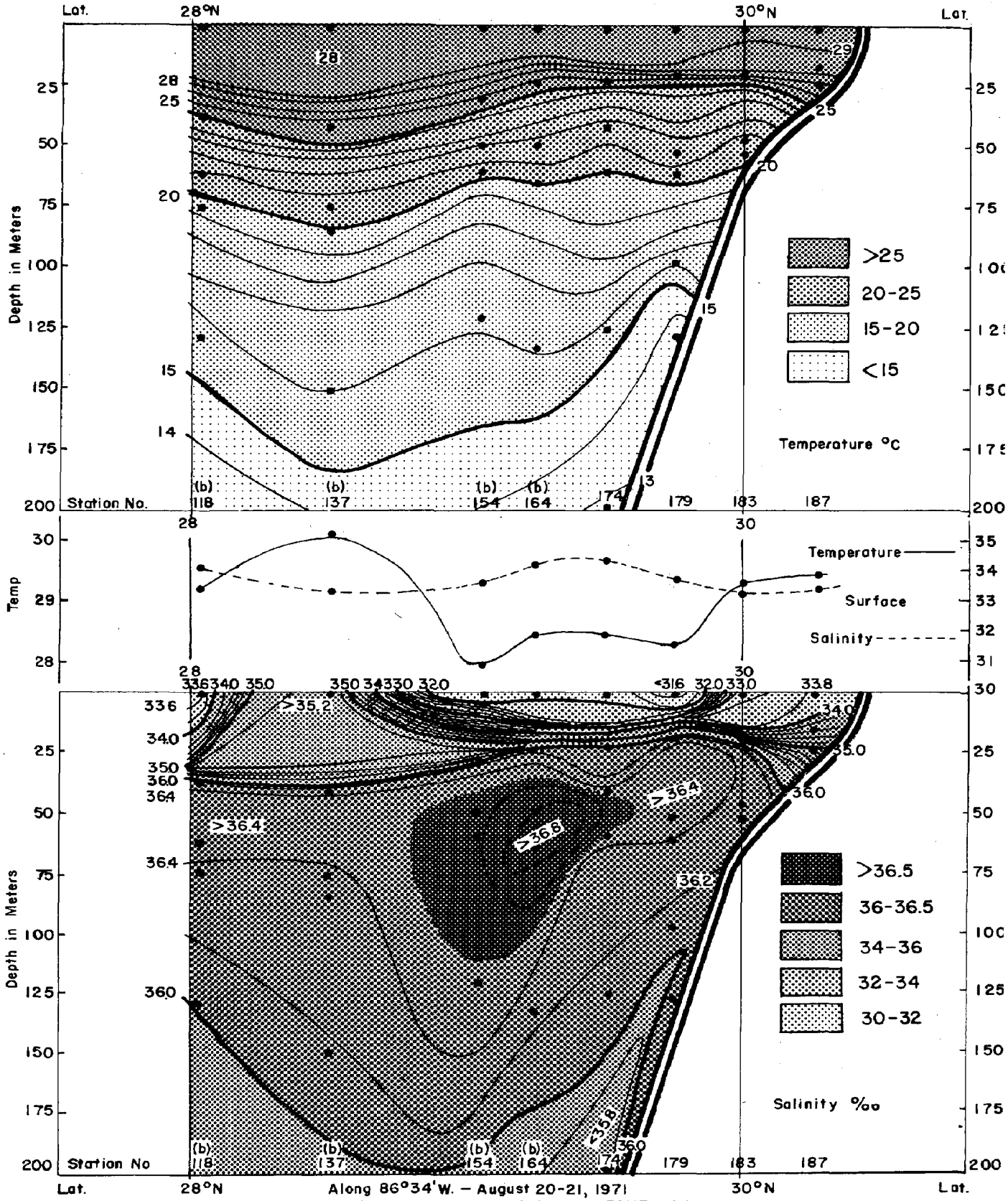


Figure 24 Vertical Distribution of Temperature and Salinity — EGMEX-IV

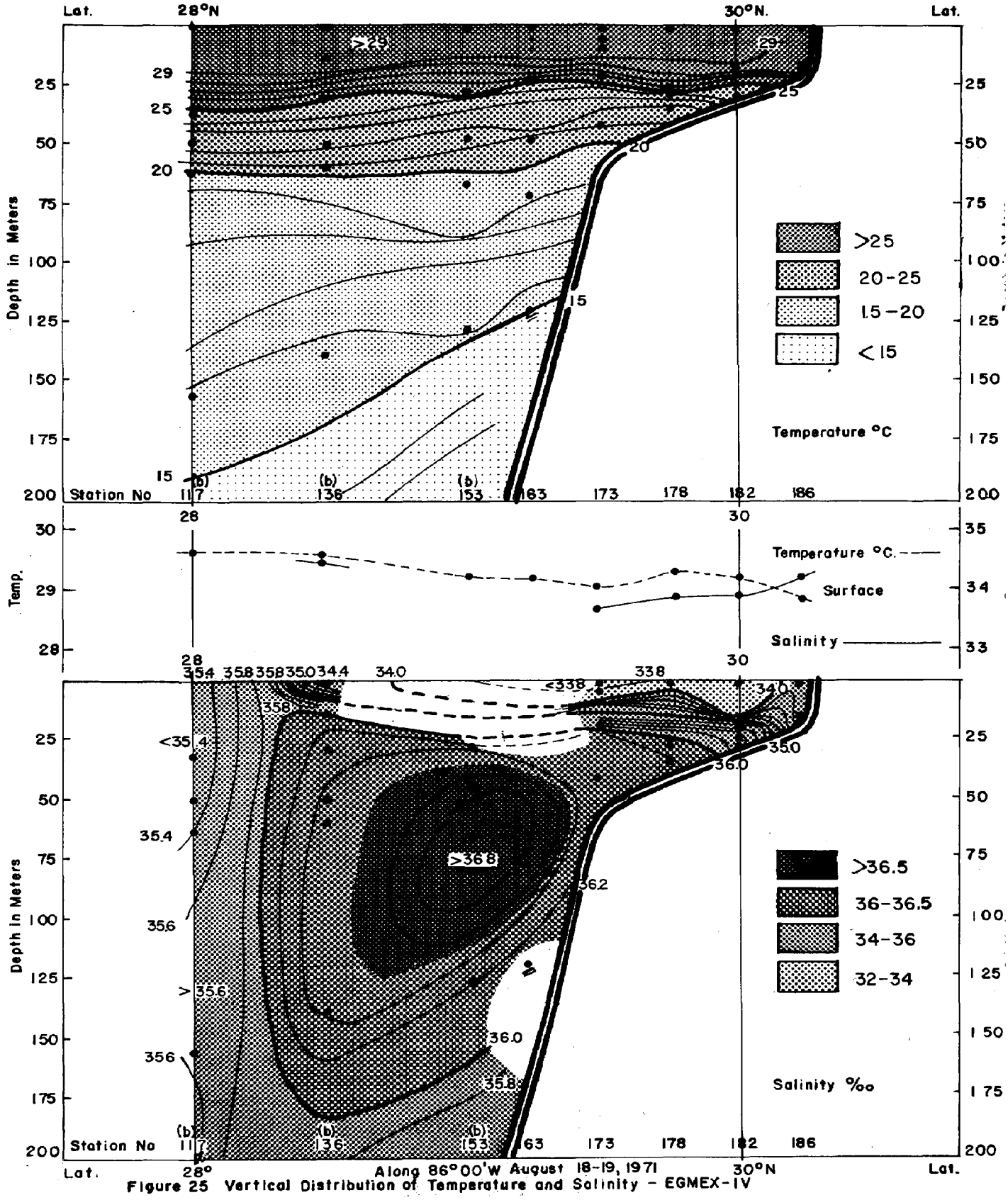


Figure 25 Vertical Distribution of Temperature and Salinity - EGMEX-IV

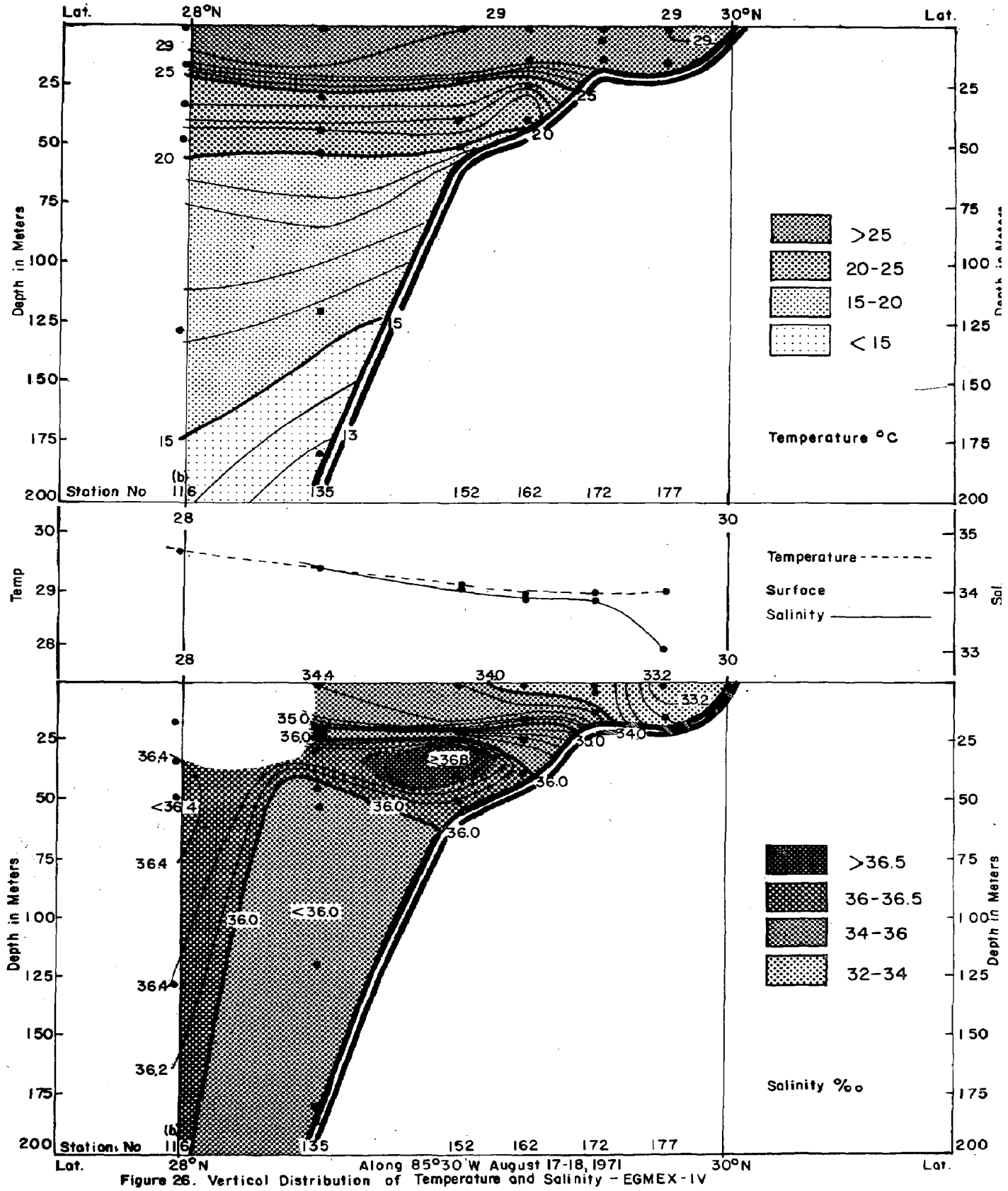


Figure 26. Vertical Distribution of Temperature and Salinity – EGMEX-IV

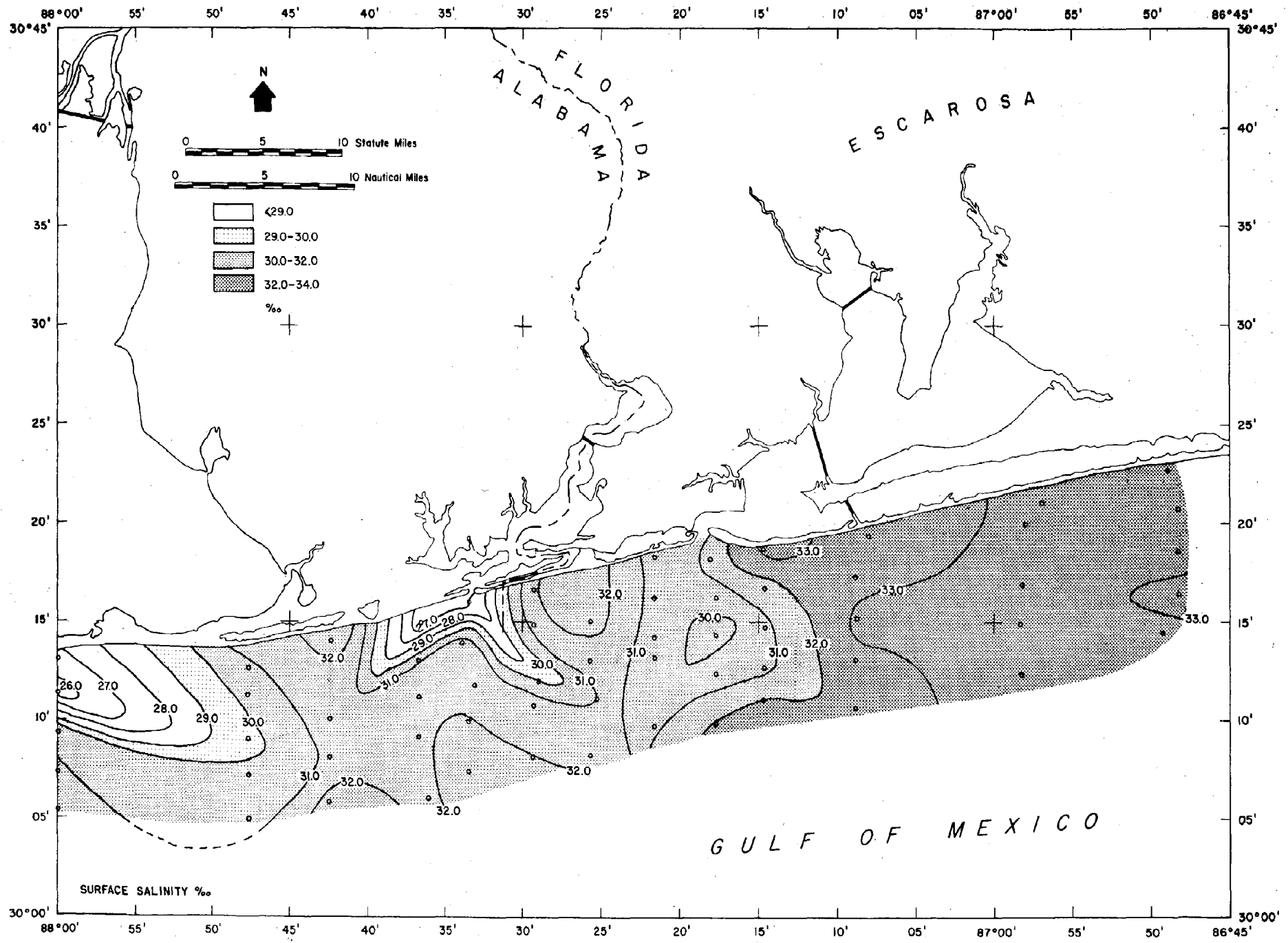


Figure 27 Surface Salinity Distribution - September 14-16, 1971

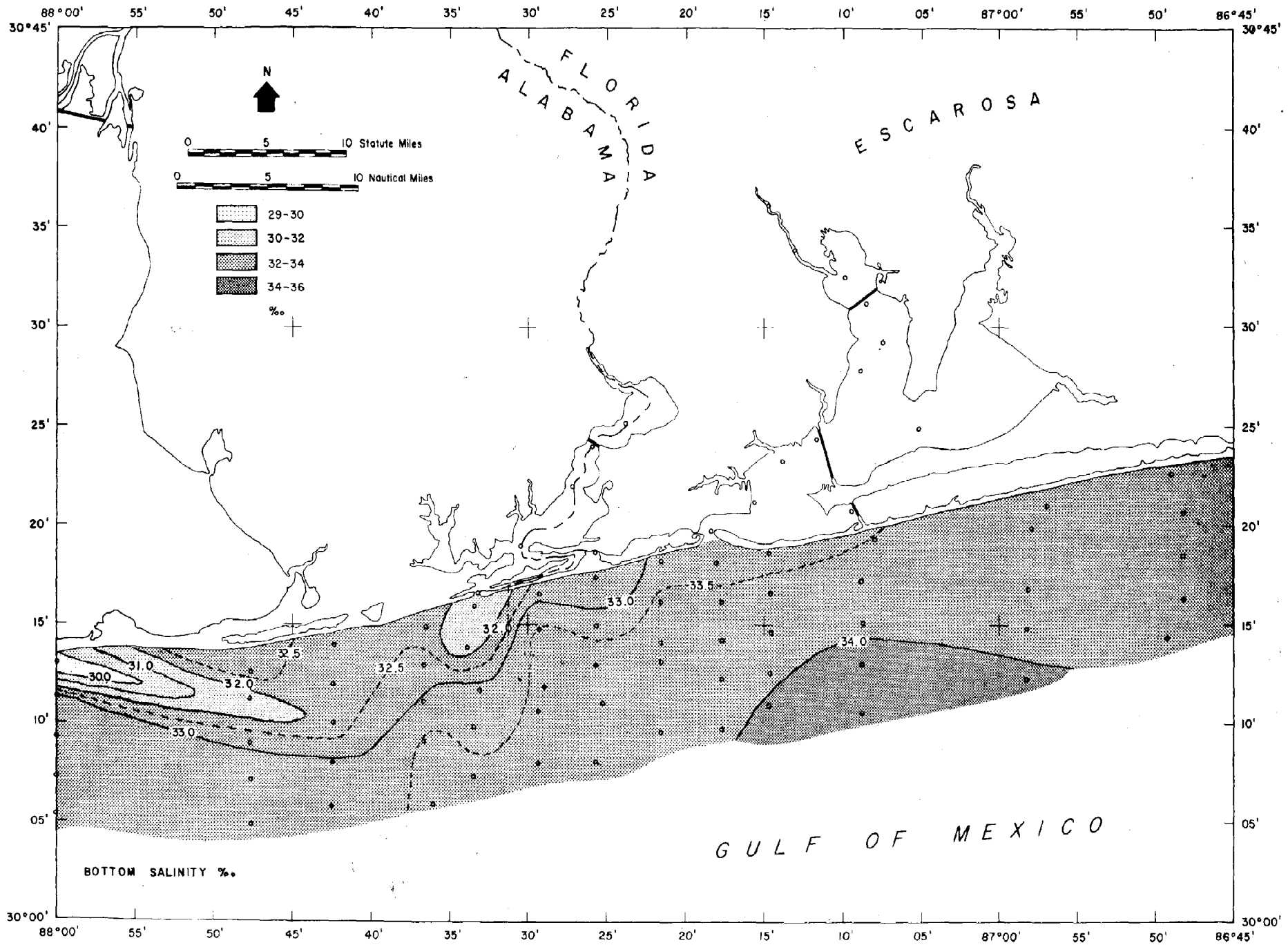


Figure 28 Bottom Salinity Distribution - September 14-16, 1971

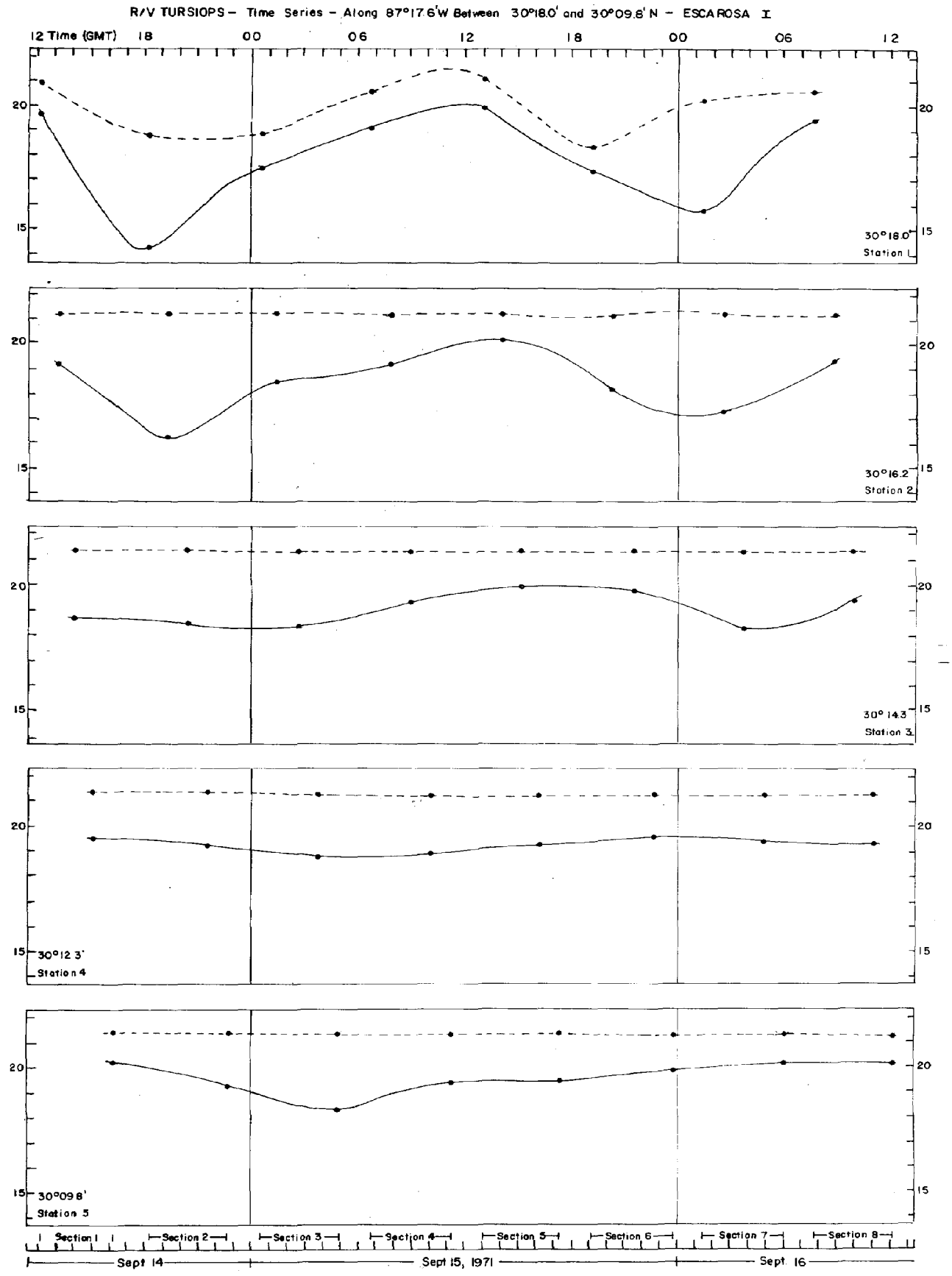


Figure 29 Sigma t

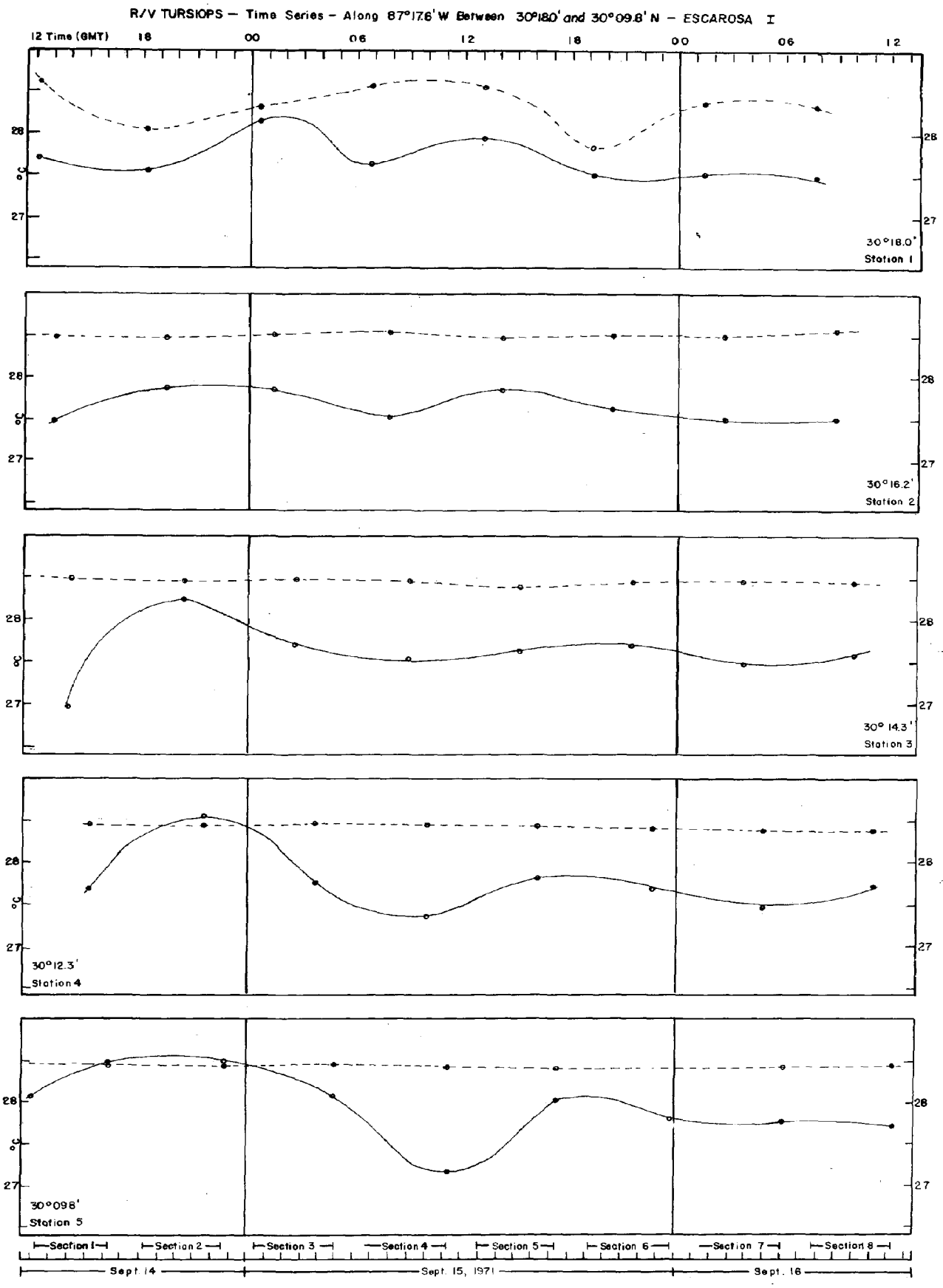


Figure 30 Temperature °C.: Surface o——o Bottom o- - - -o

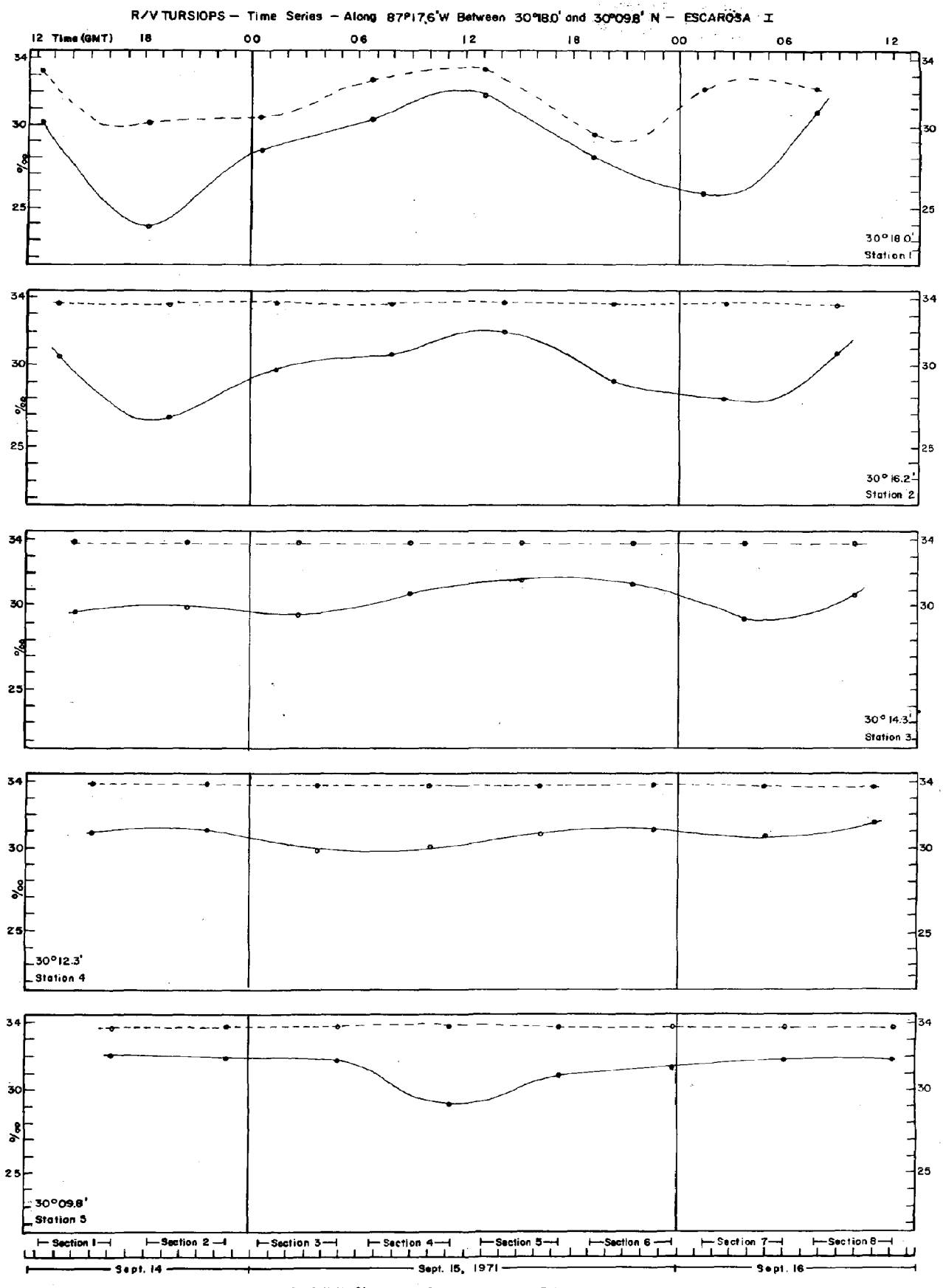


Figure 31 Salinity ‰ Surface ——— Bottom - - - - - -

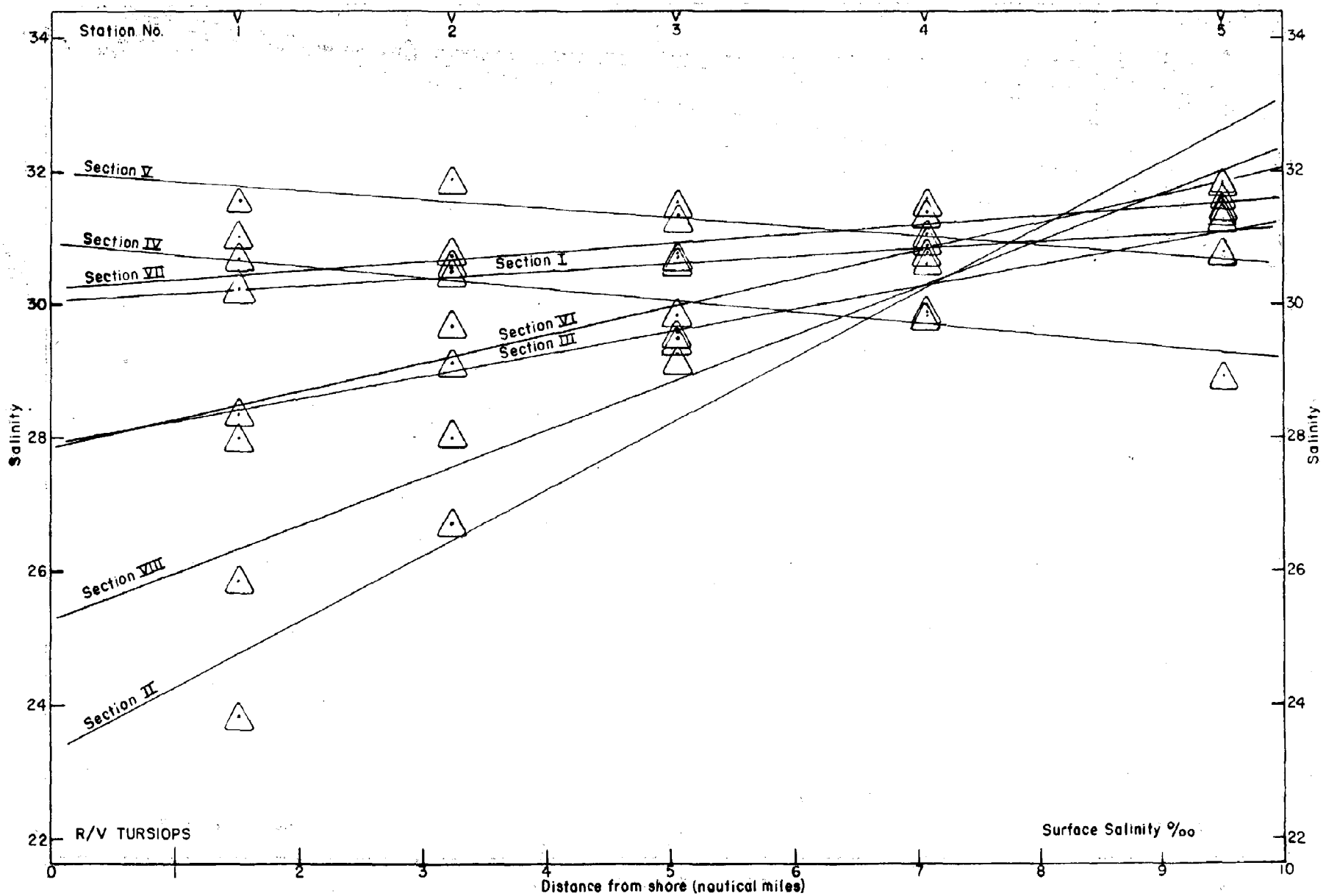


Figure 32. Linear regression lines between surface salinity and distance from shore.

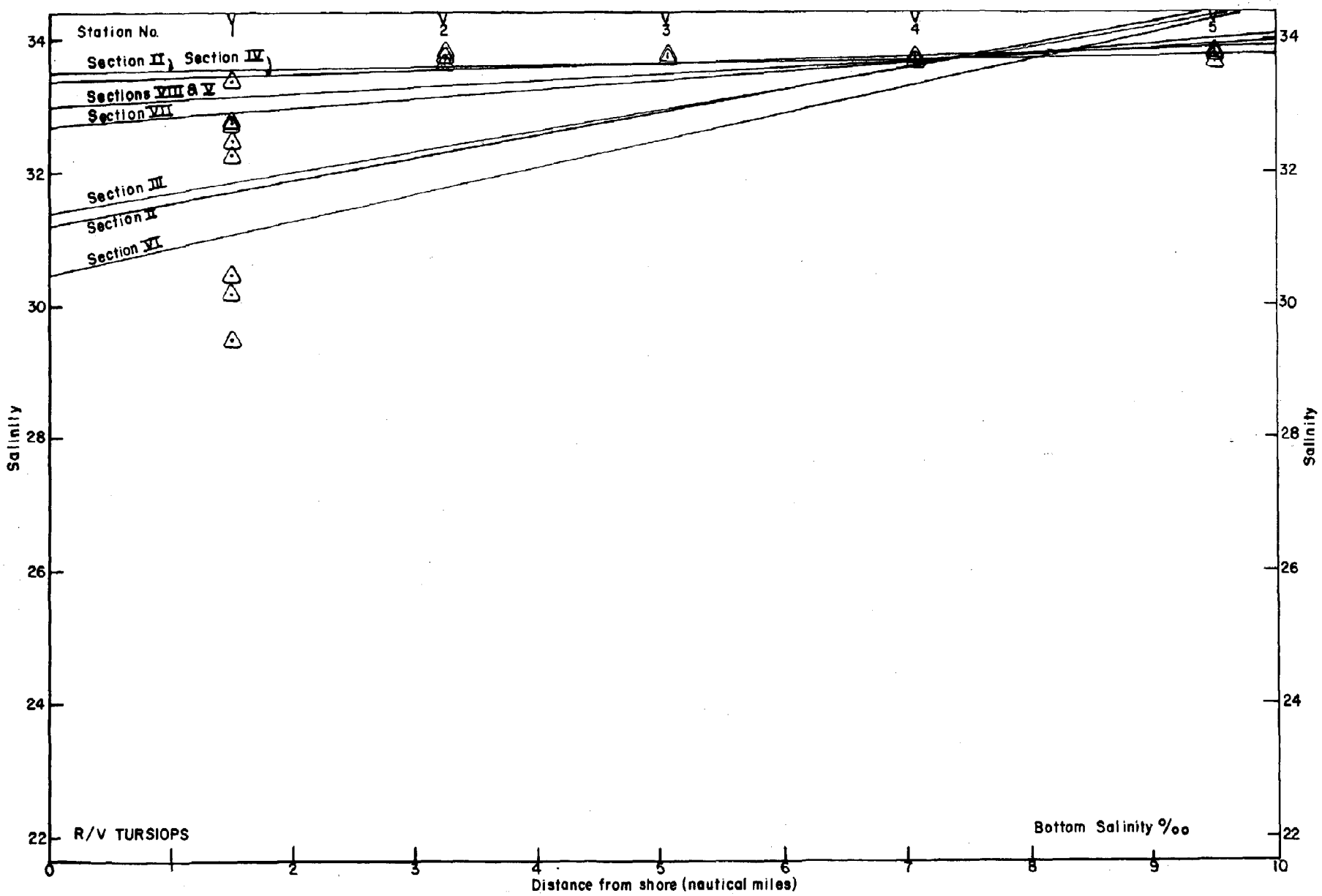


Figure 33. Linear regression lines between bottom salinity and distance from shore.

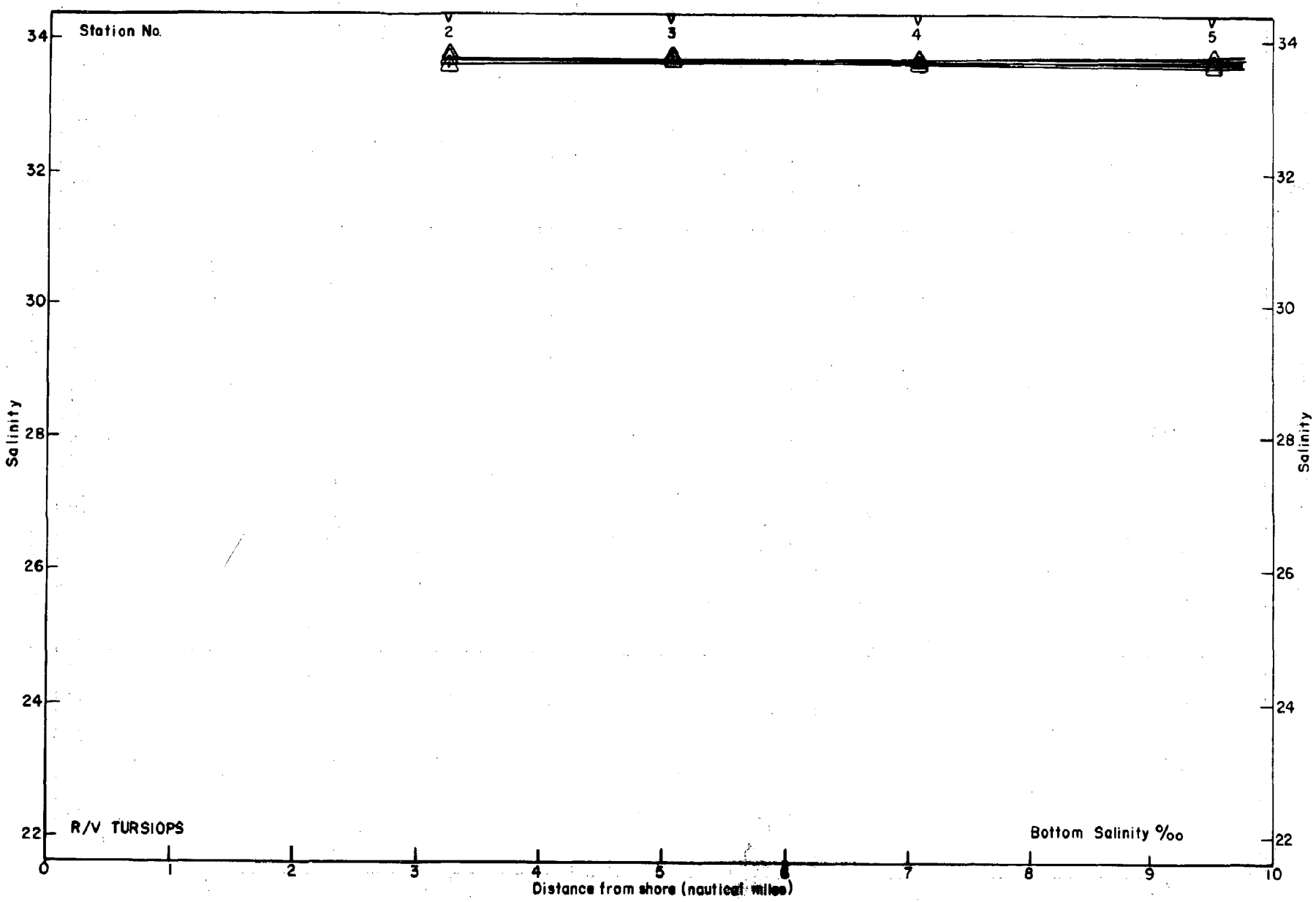


Figure 34. Linear regression lines between bottom salinity and distance from shore.

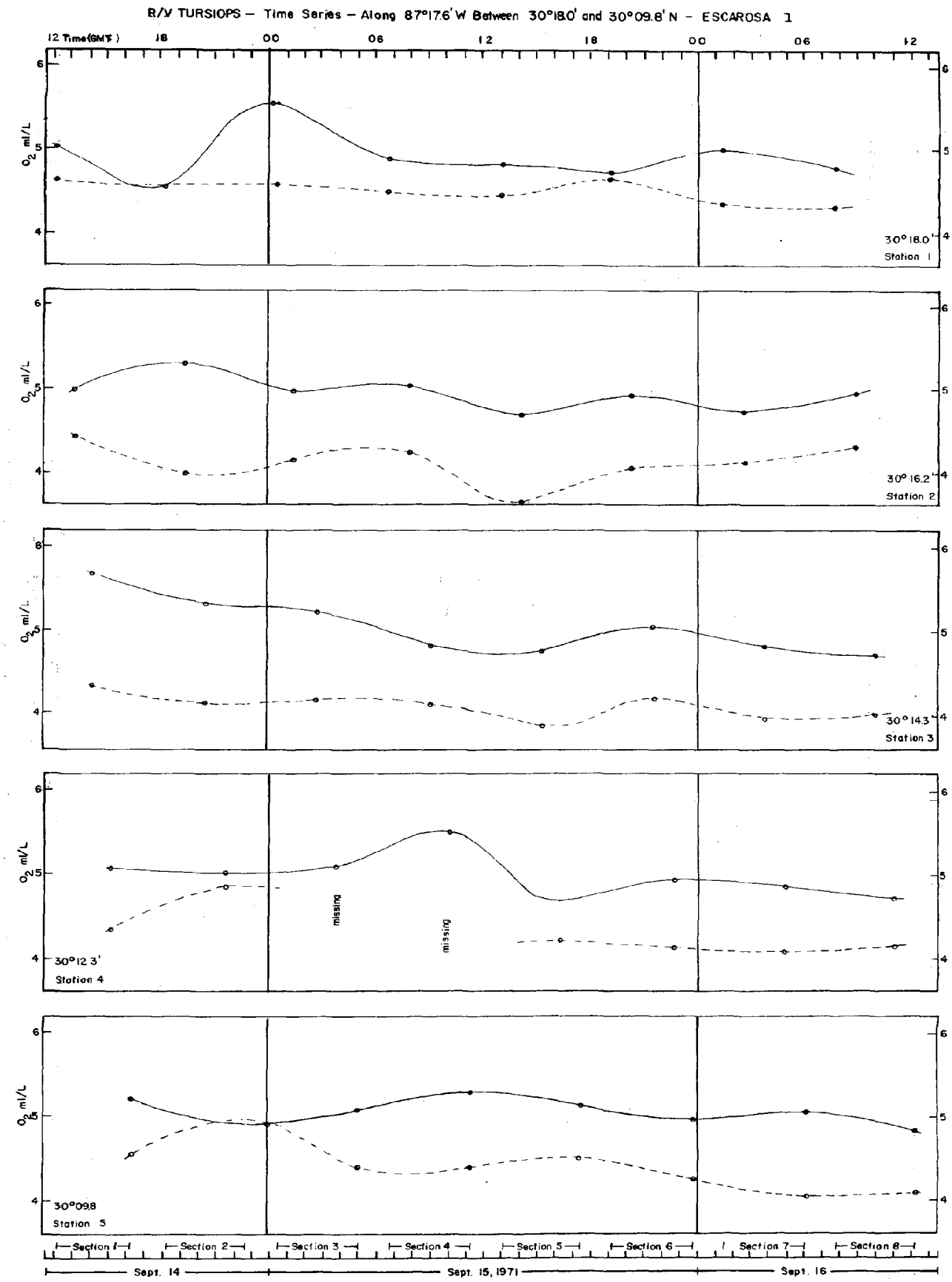


Figure 35 Oxygen ml/L Surface ——— Bottom - - - - - -

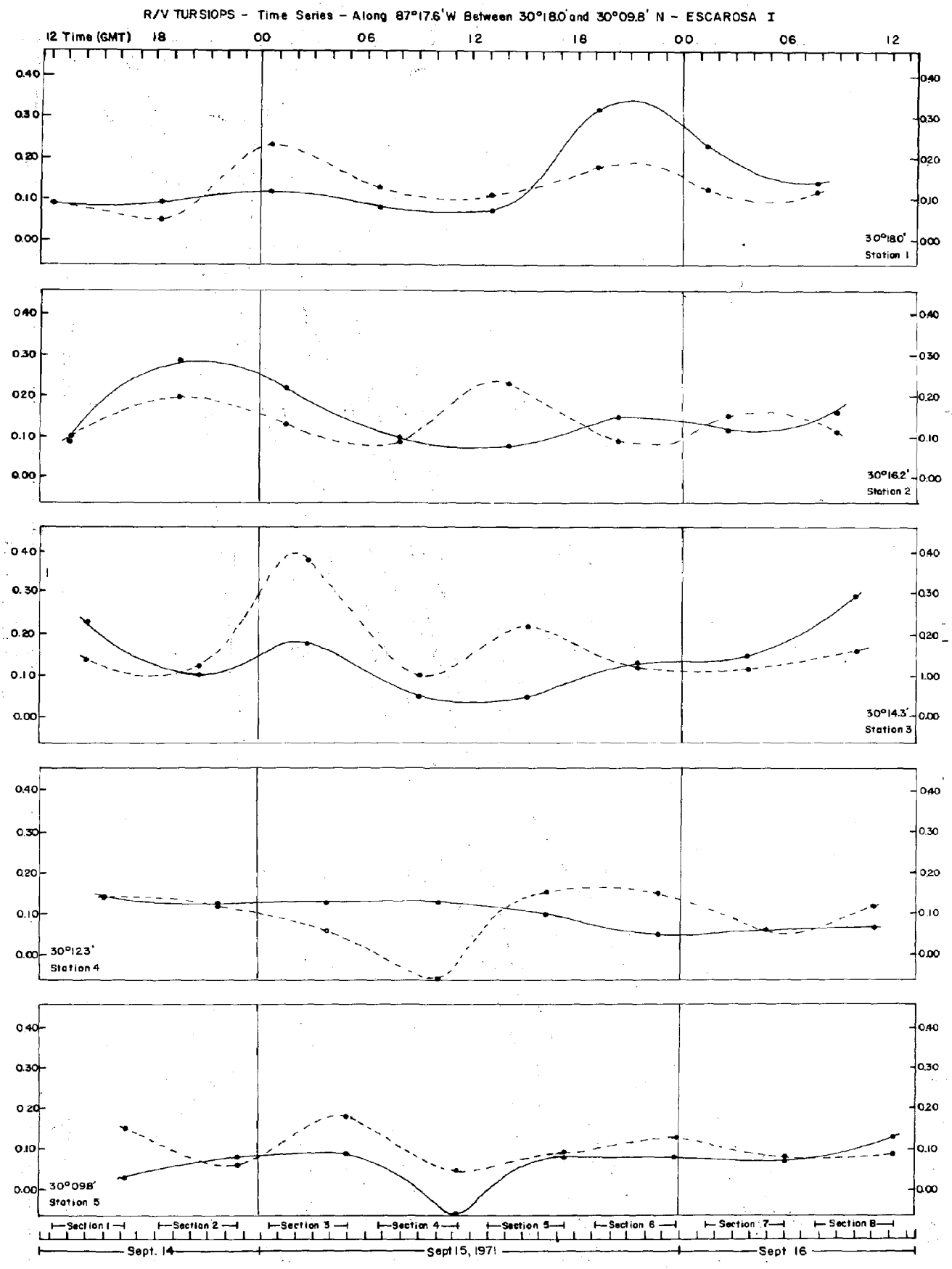


Figure 36 PO_4-P µg a.t/l Surface ——— Bottom - - - - - -

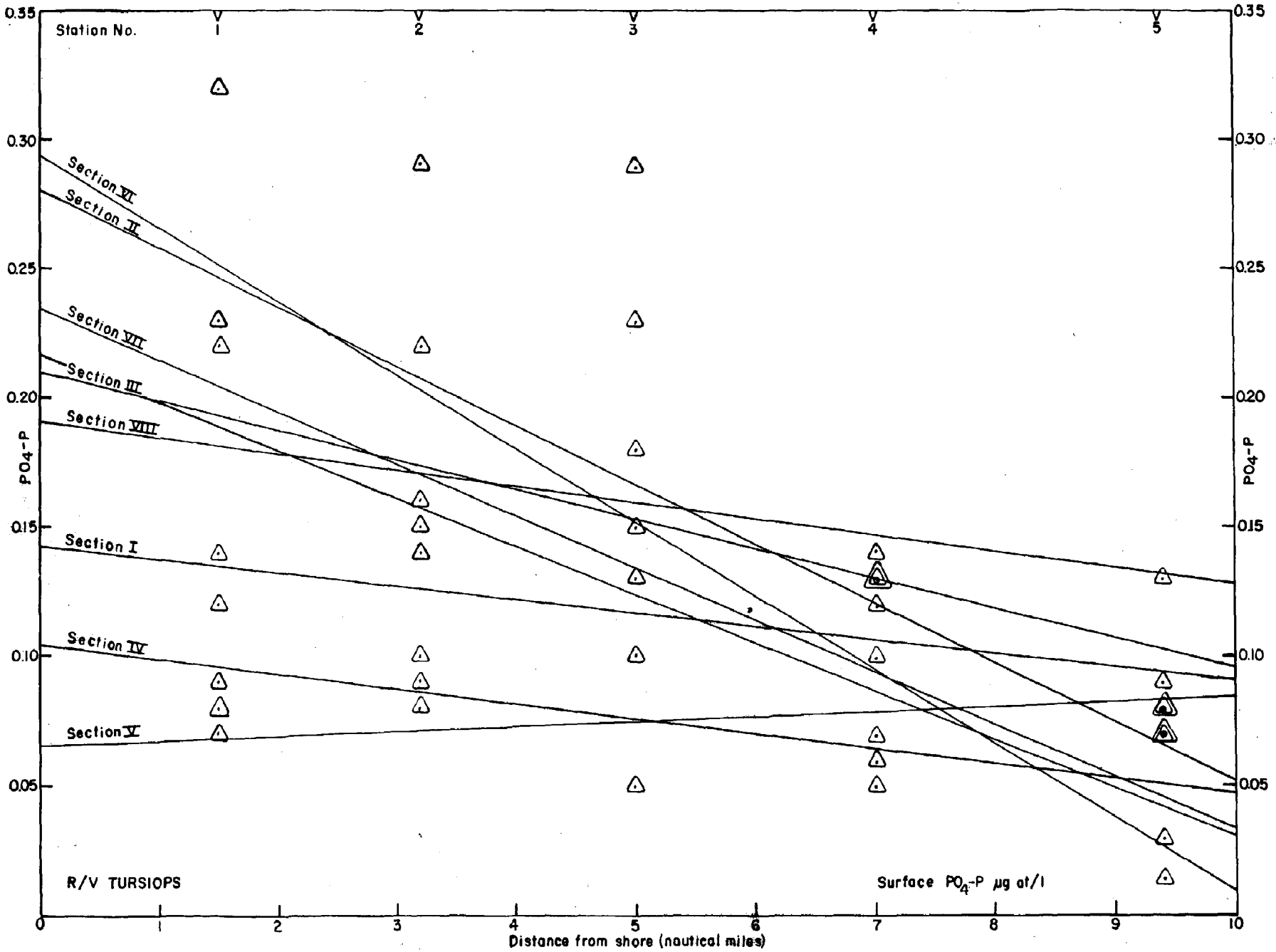


Figure 37. Linear regression lines between surface inorganic phosphorus phosphate and distance from shore

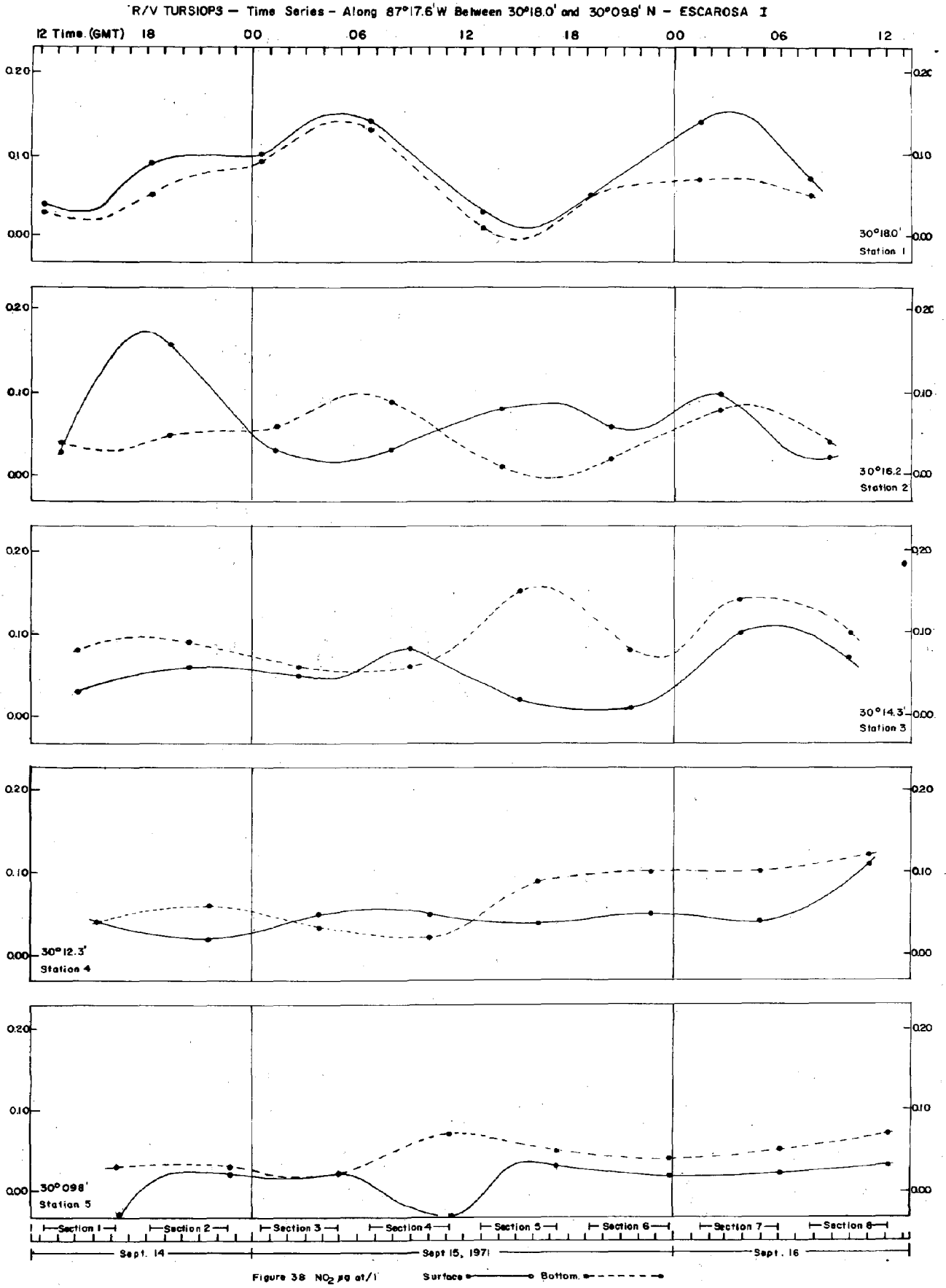


Figure 38 NO_2 µg at/l Surface ——— Bottom - - - - -

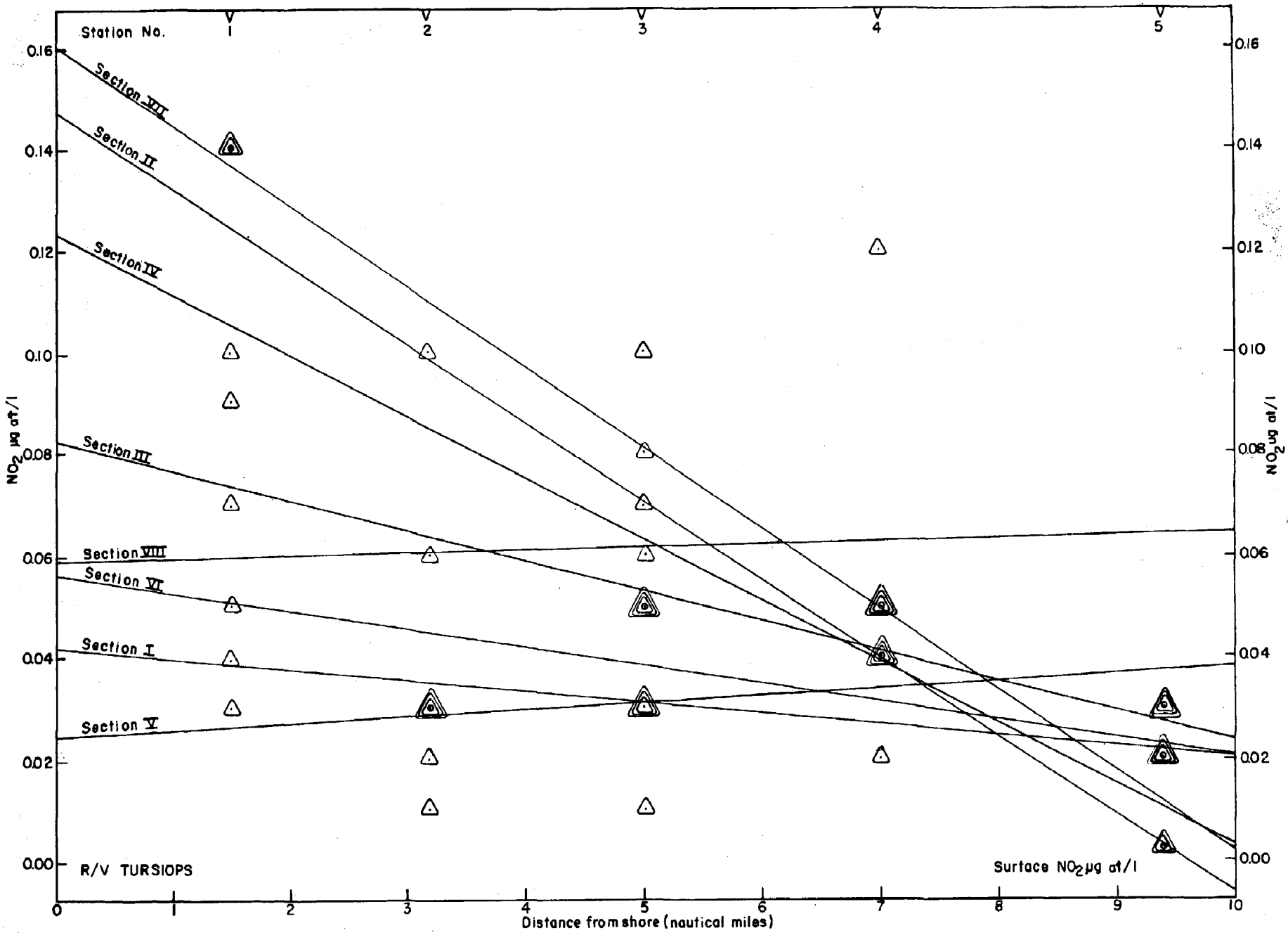


Figure 39. Linear regression lines between surface nitrite-nitrogen and distance from shore.

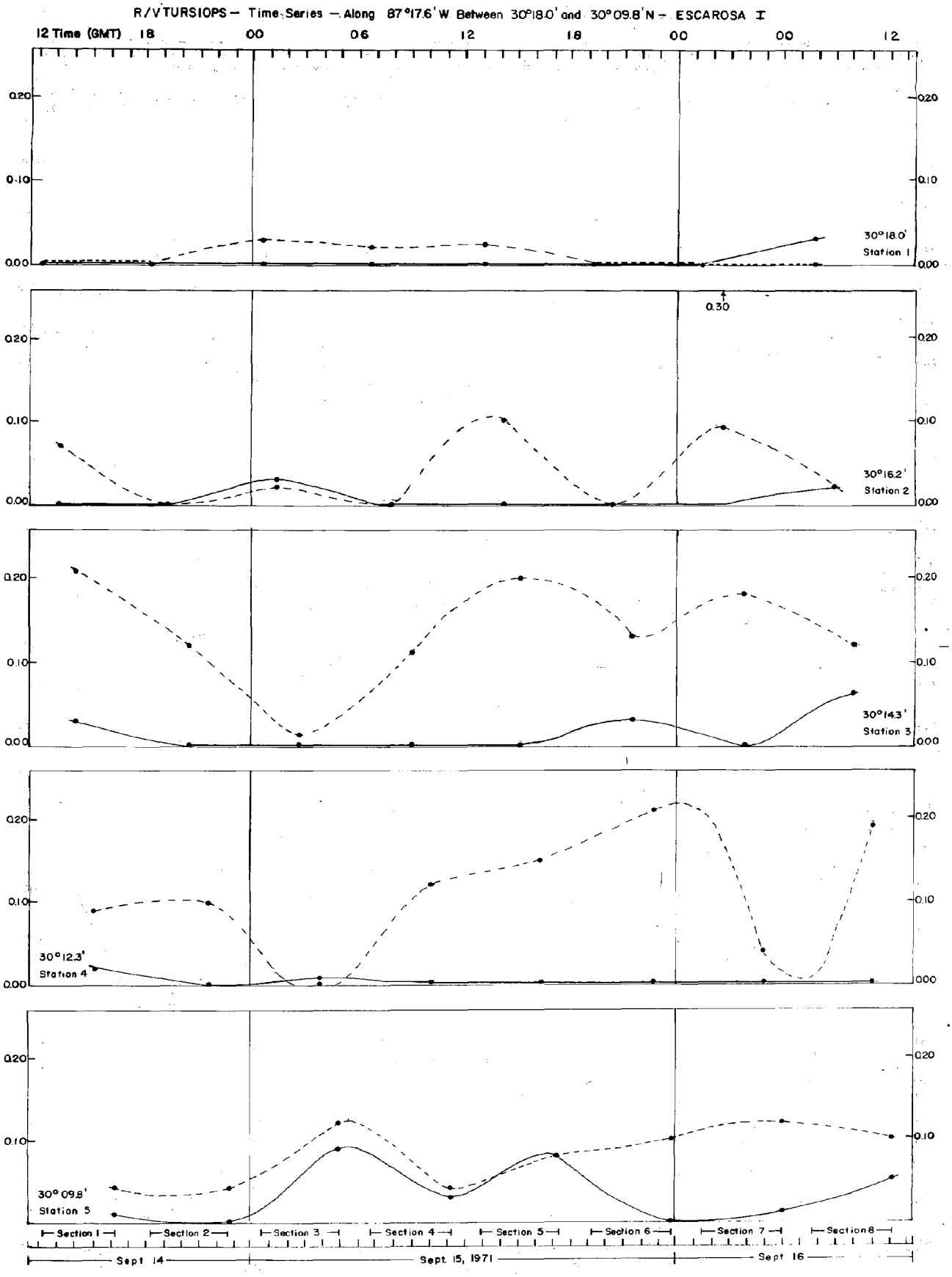


Figure 40. NO_3 µg.at/l Surface o——o Bottom o- - - - -o

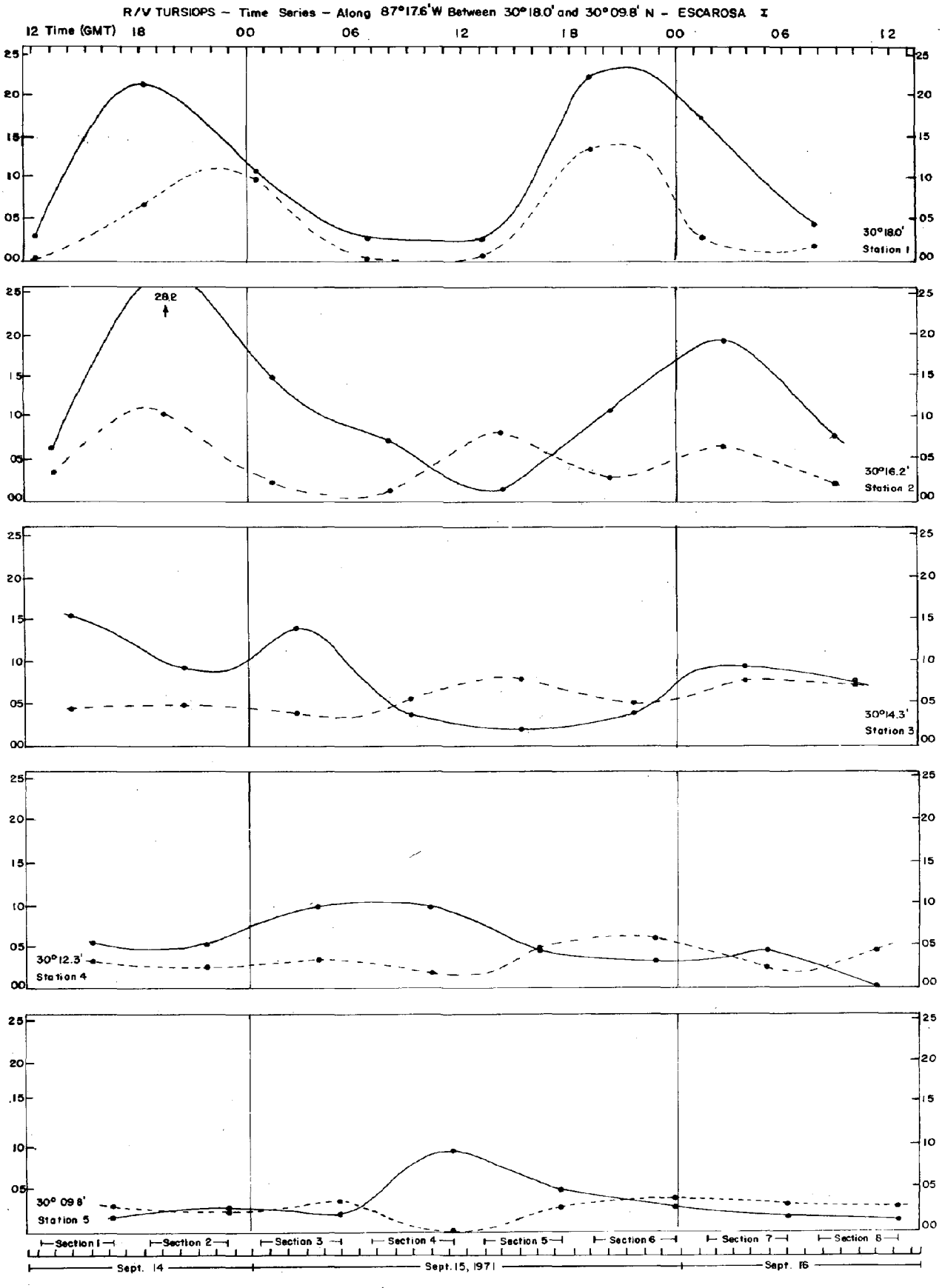


Figure 41. SiO_3 µg at/l Surface ——— Bottom - - - - - -

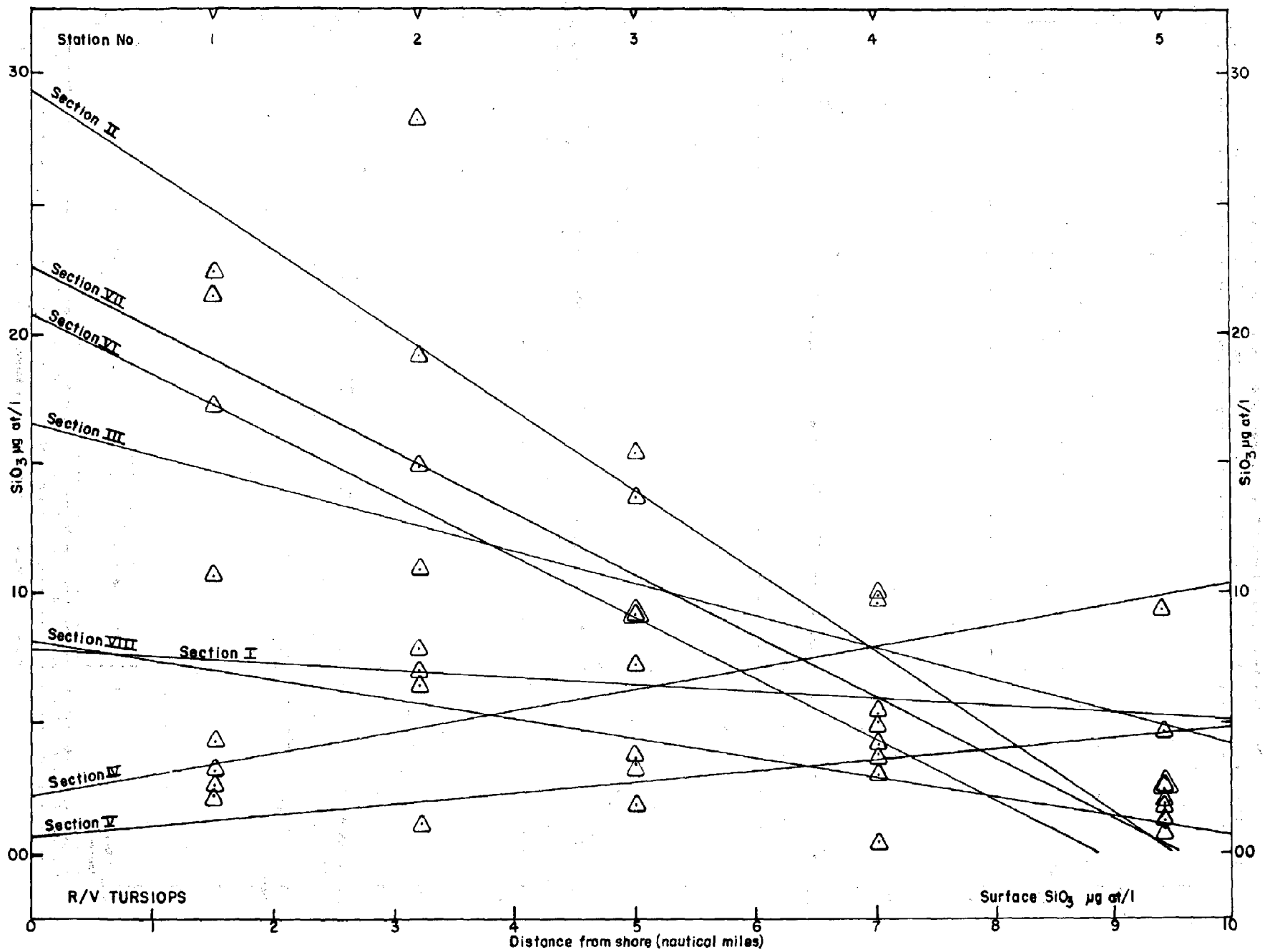


Figure 42. Linear regression lines between surface silica and distance from shore

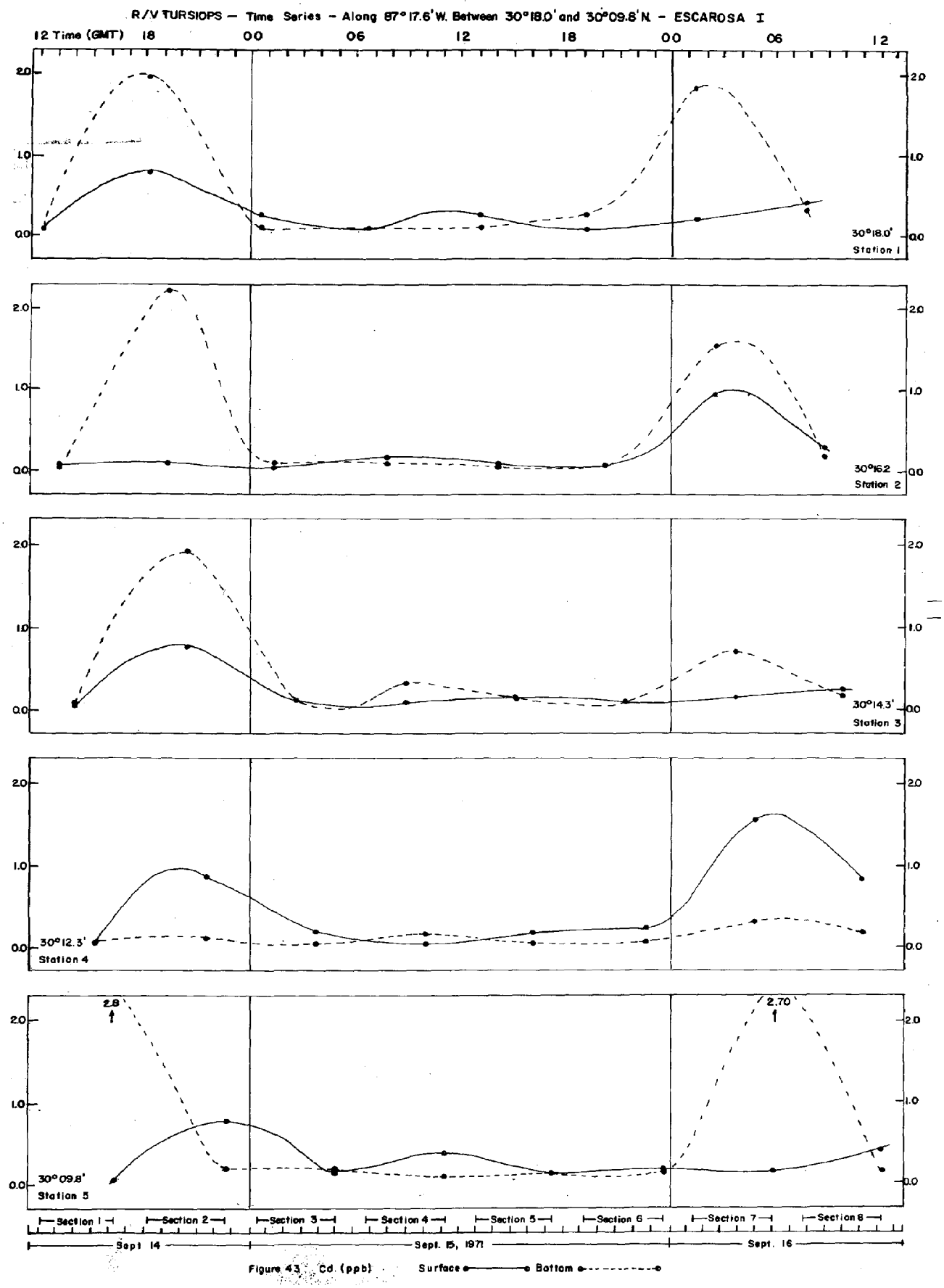


Figure 43 Cd. (ppb) Surface ——— Bottom - - - - - -

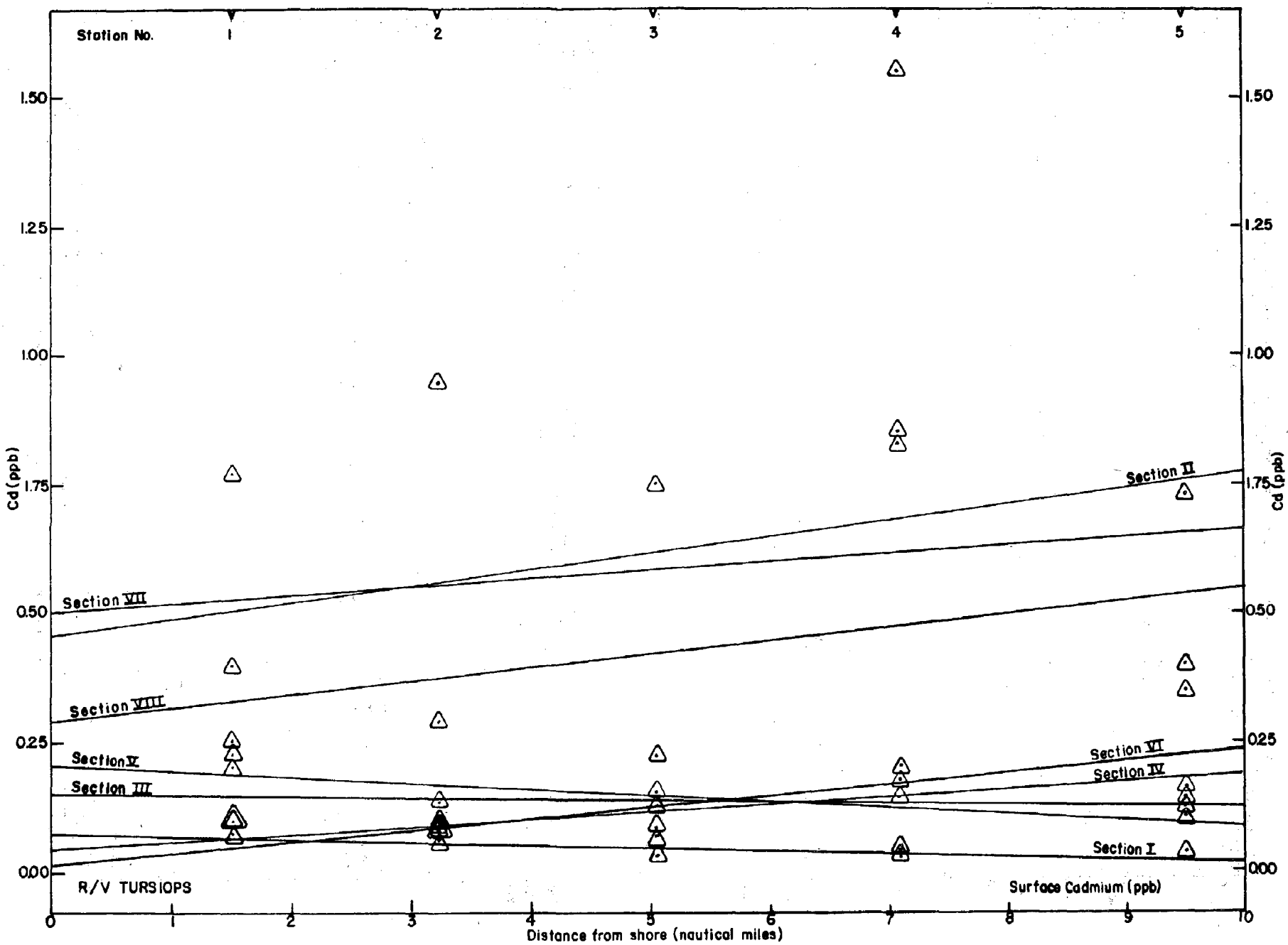


Figure 44. Linear regression lines between surface cadmium and distance from shore

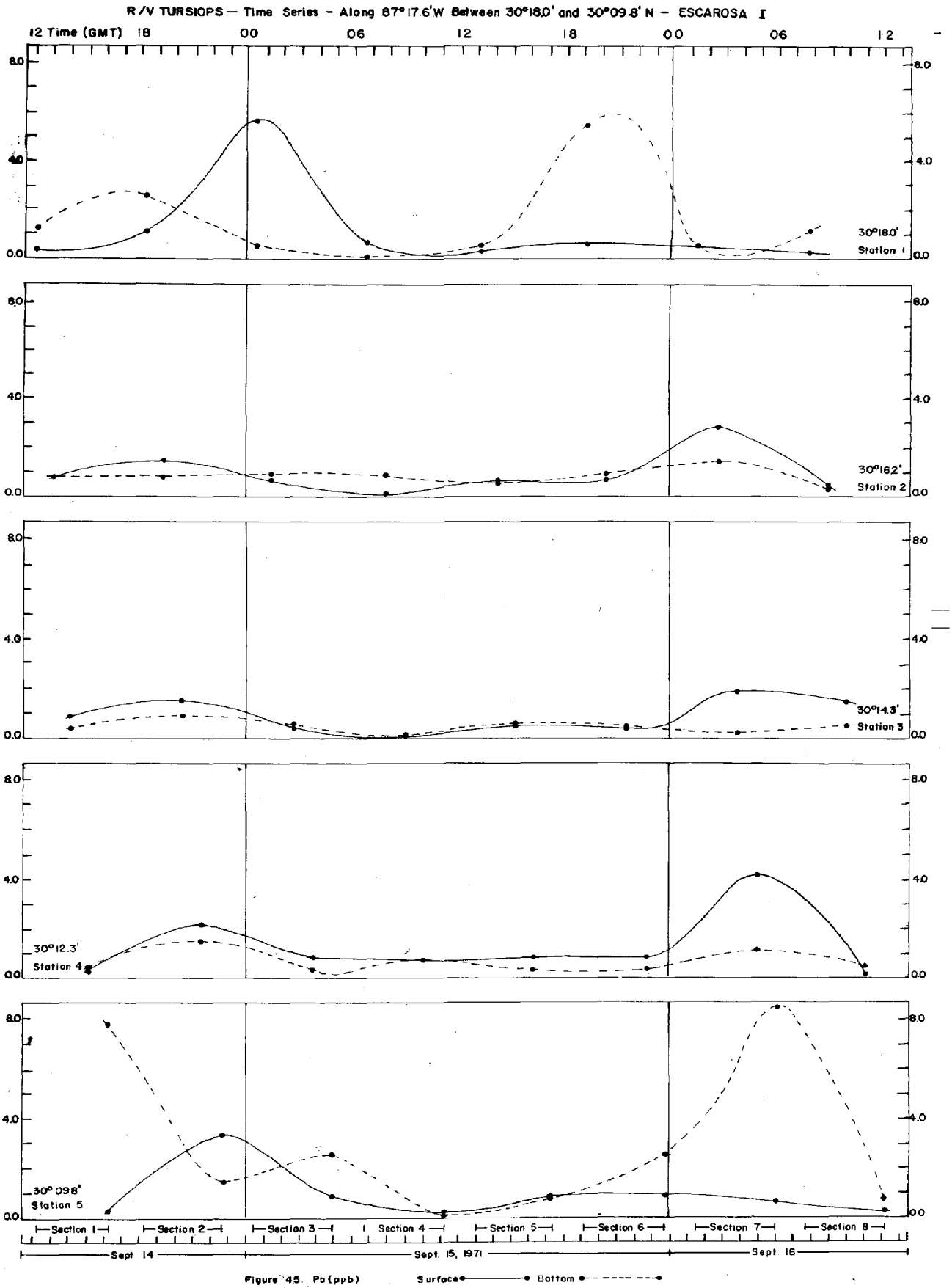


Figure 45. Pb (ppb) Surface ——— Bottom - - - - -

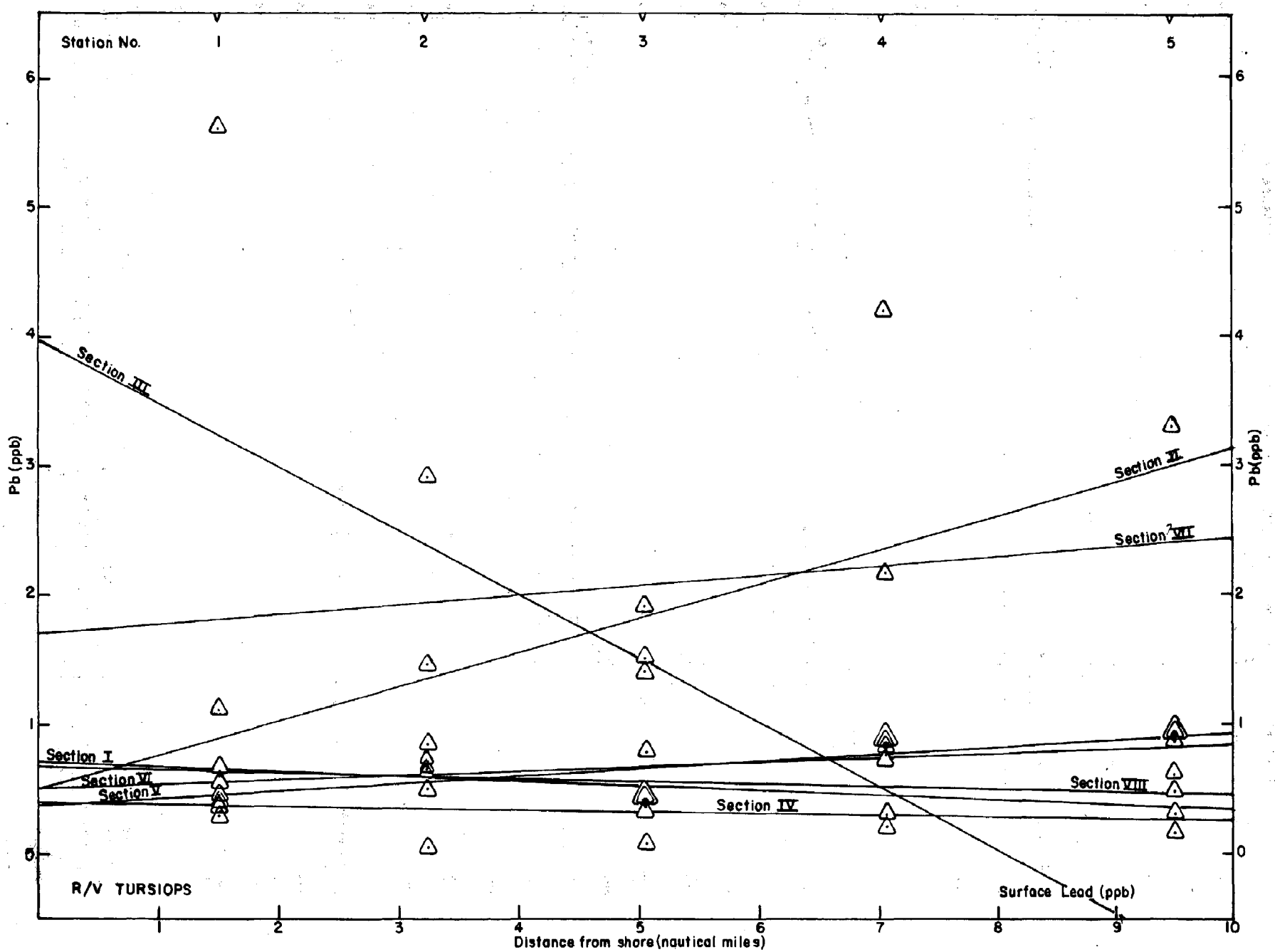


Figure 46. Linear regression lines between surface lead and distance from shore

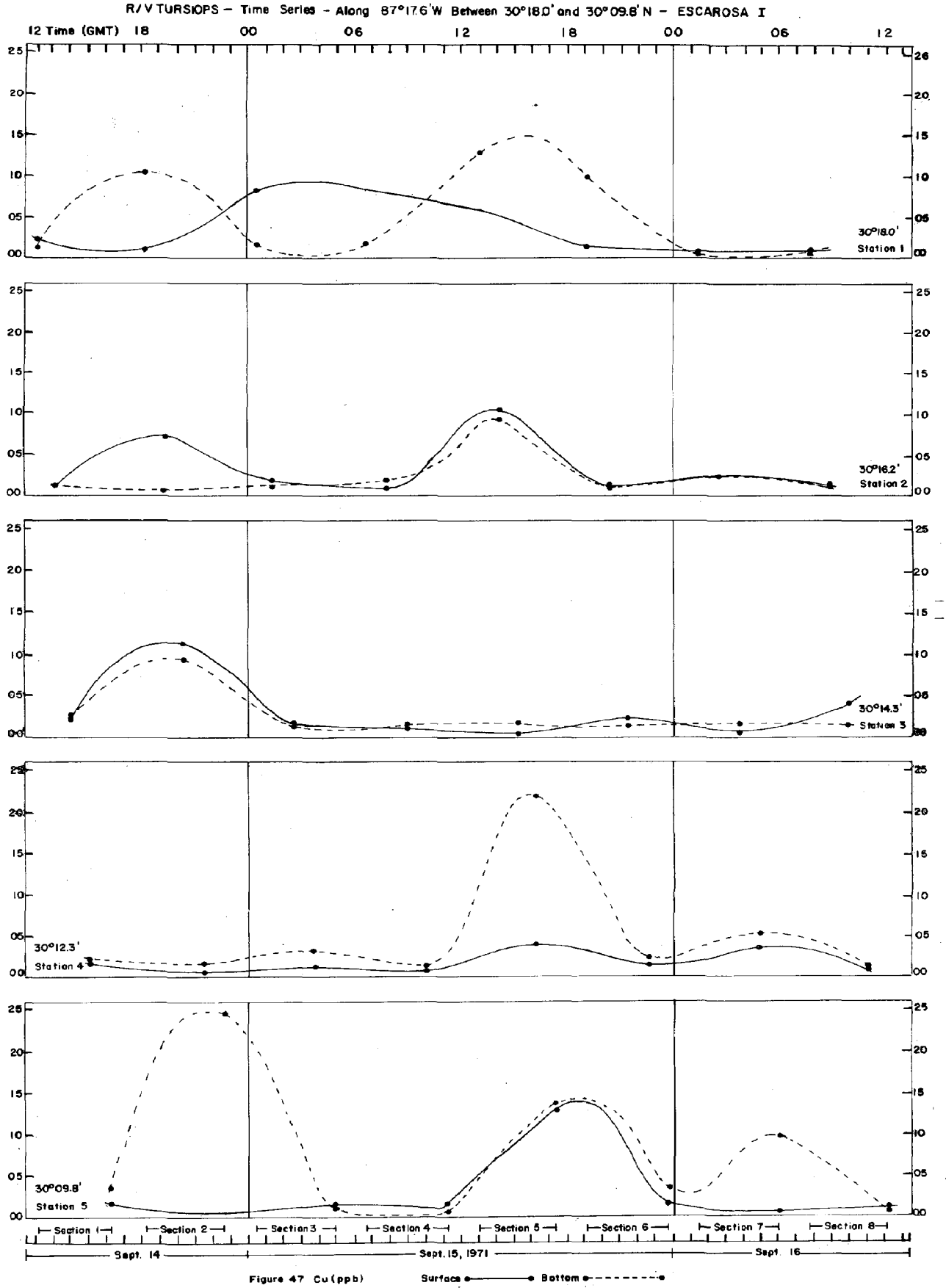


Figure 47 Cu (ppb) Surface ——— Bottom - - - - - -

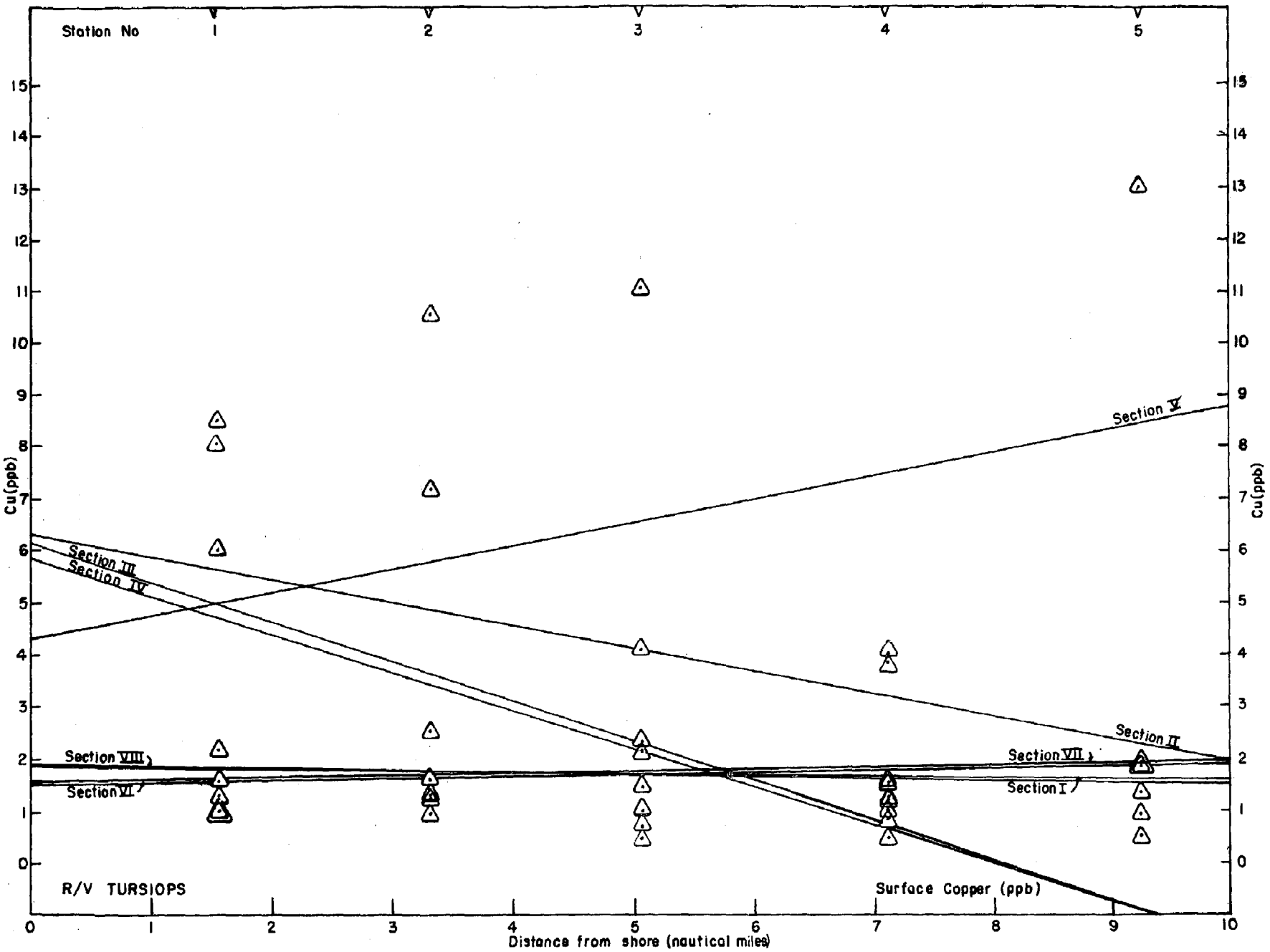


Figure 48. Linear regression lines between surface copper and distance from shore

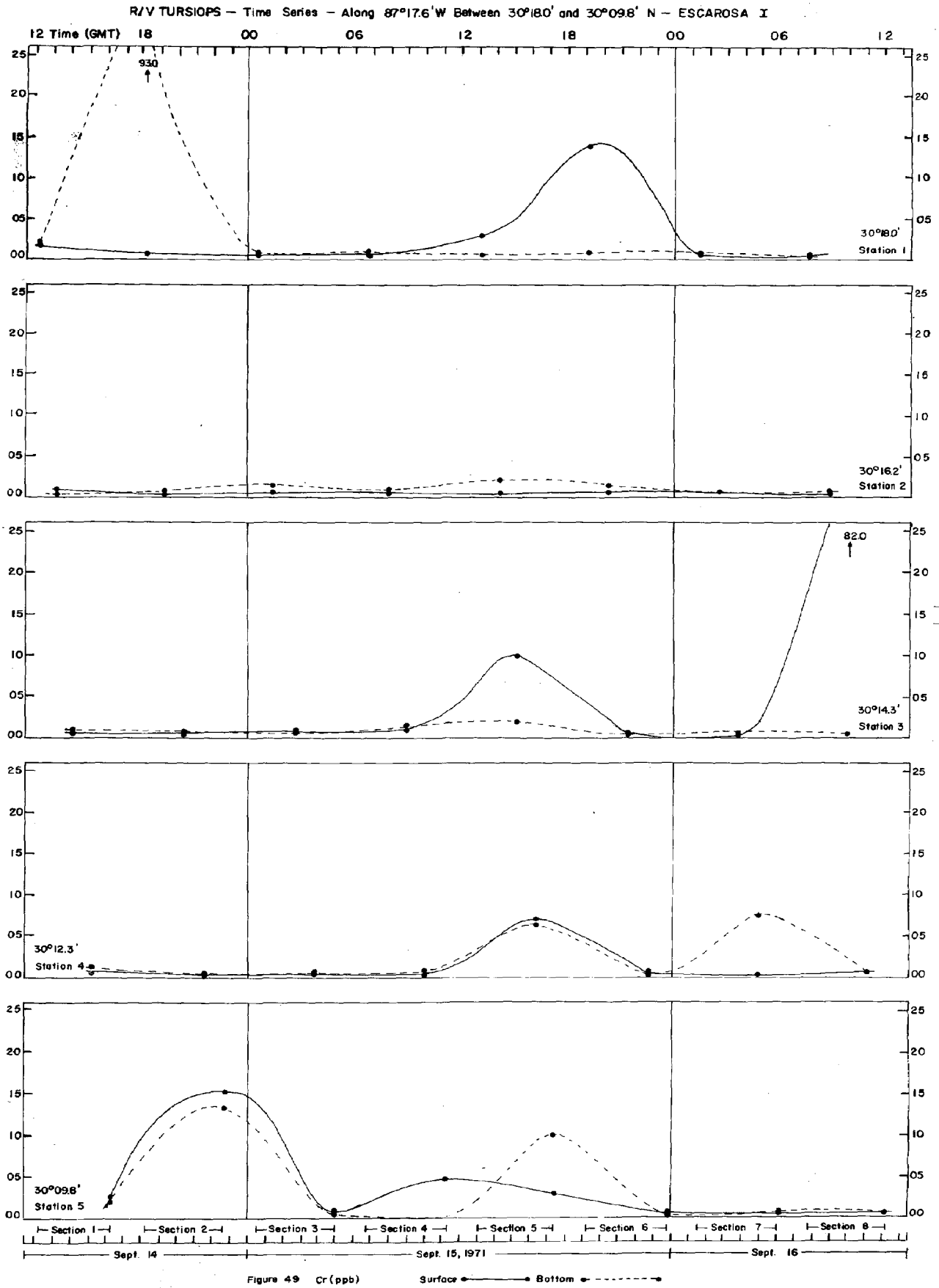


Figure 49 Cr (ppb) Surface ——— Bottom - - - - - -

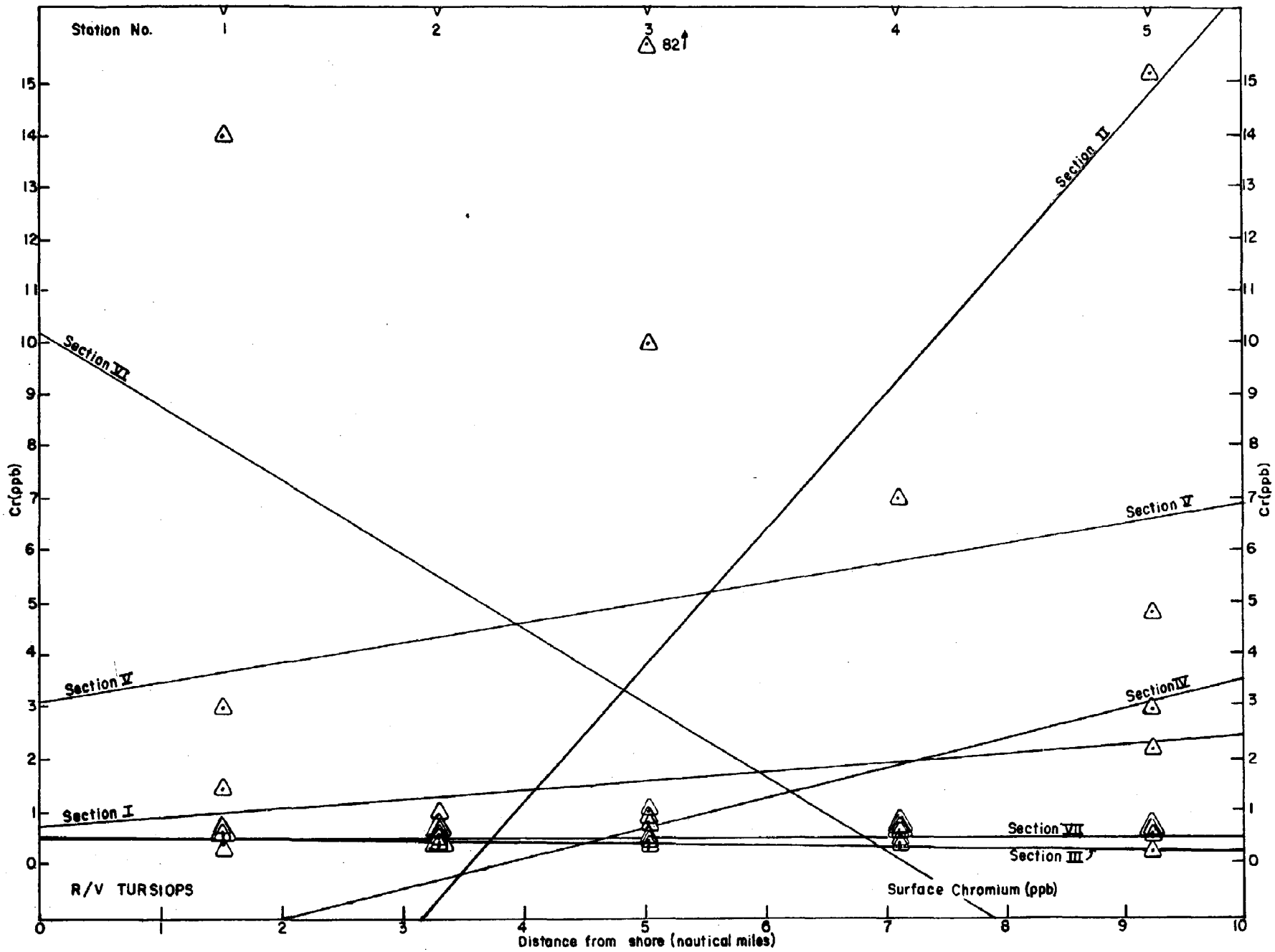


Figure 50. Linear regression lines between surface chromium and distance from shore

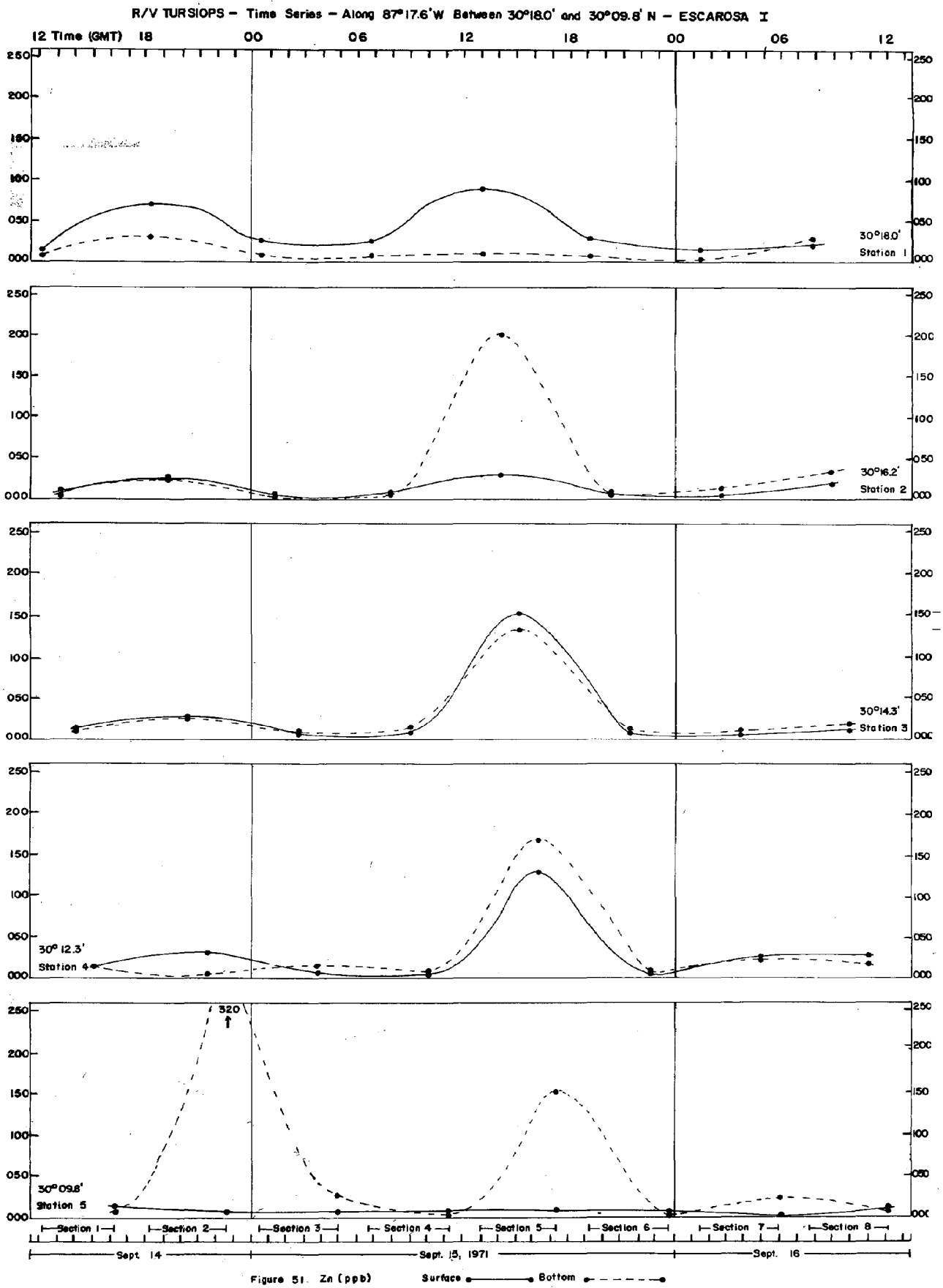


Figure 51. Zn (ppb) Surface ——— Bottom - - - - -

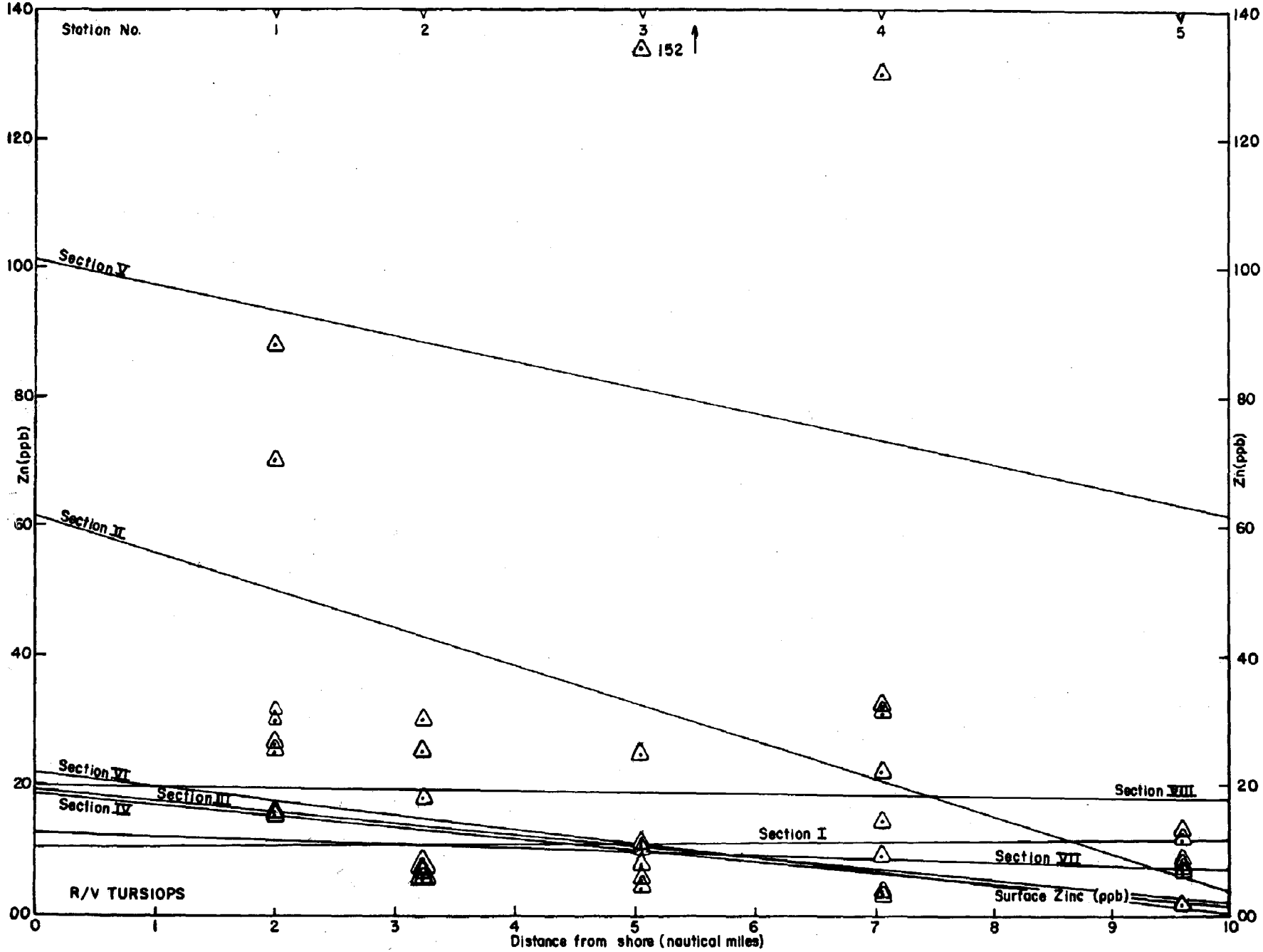


Figure52. Linear regression lines between surface zinc and distance from shore

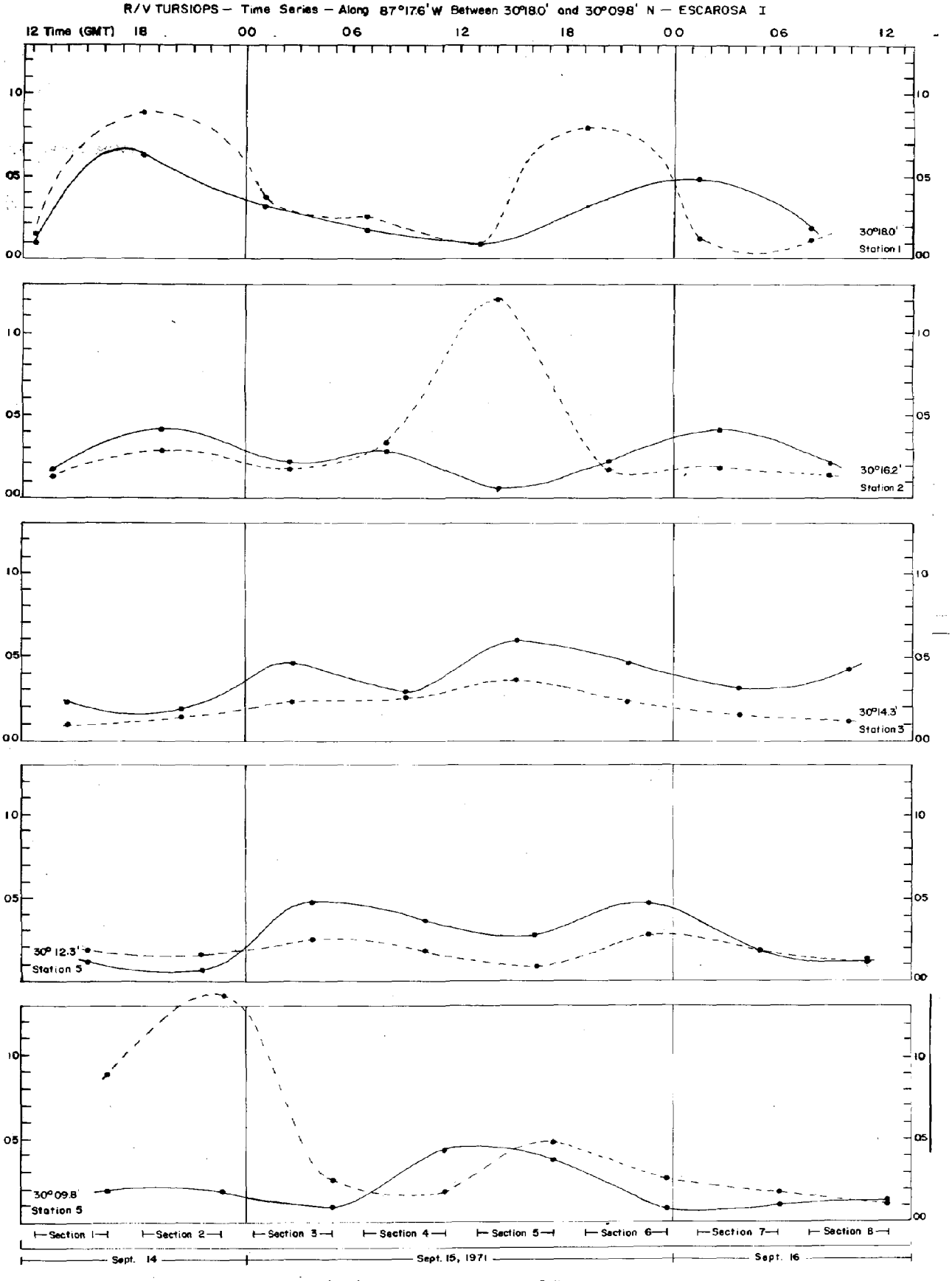


Figure 53 Mn(ppb) Surface ——— Bottom - - - - -

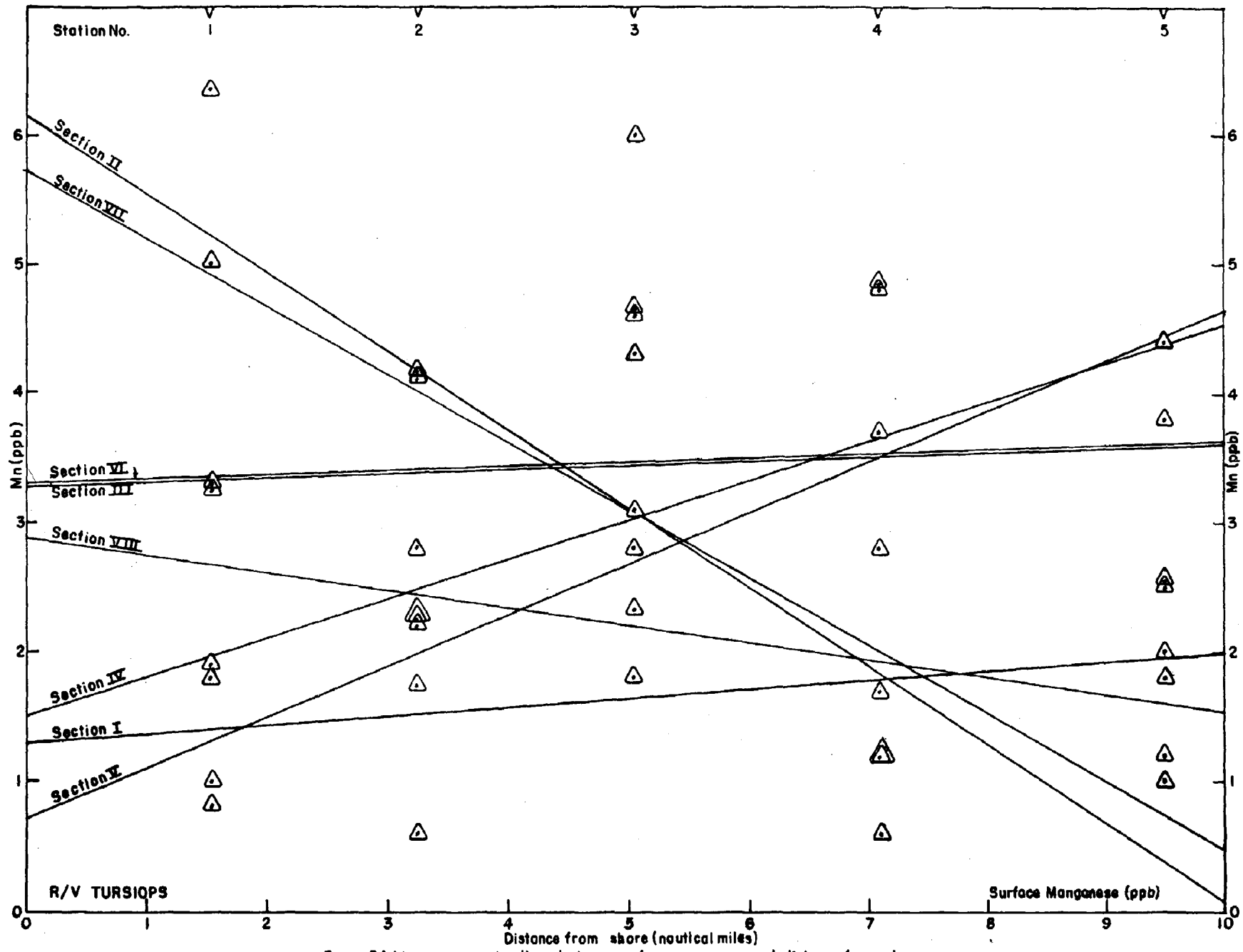


Figure 54. Linear regression lines between surface manganese and distance from shore

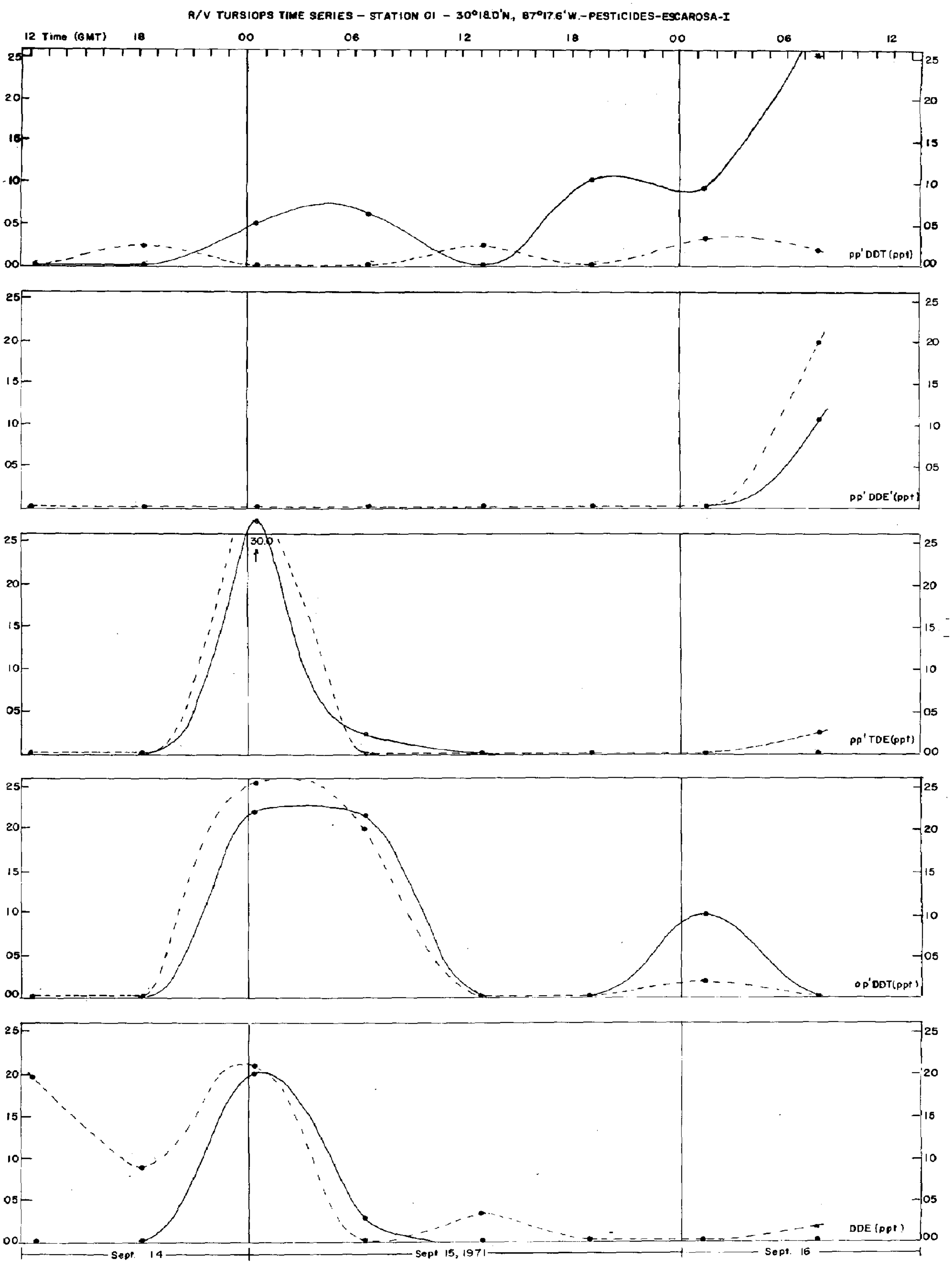


Figure 55 Pesticides at Surface •- - - - - - - - -• Bottom •- - - - - - - - -•

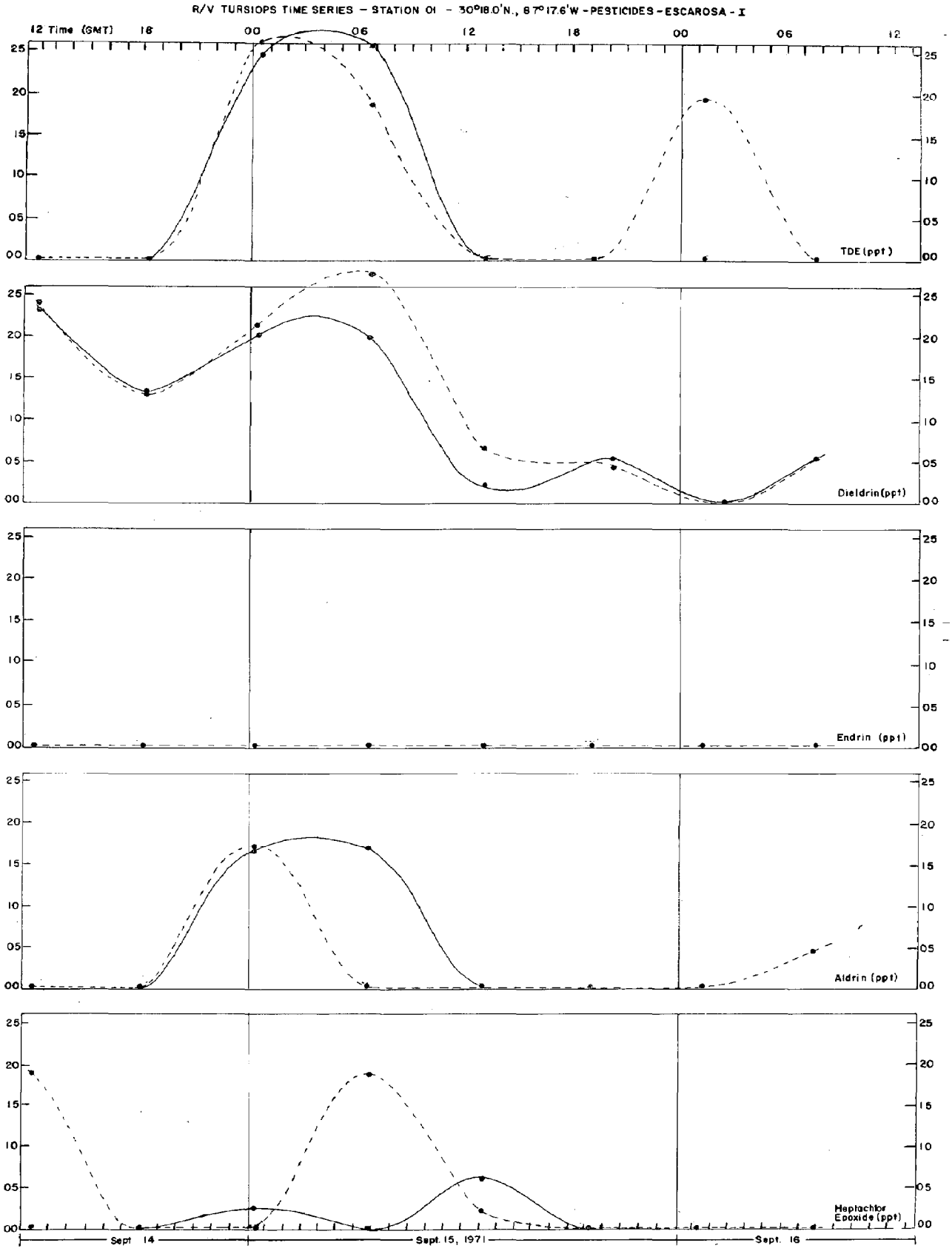
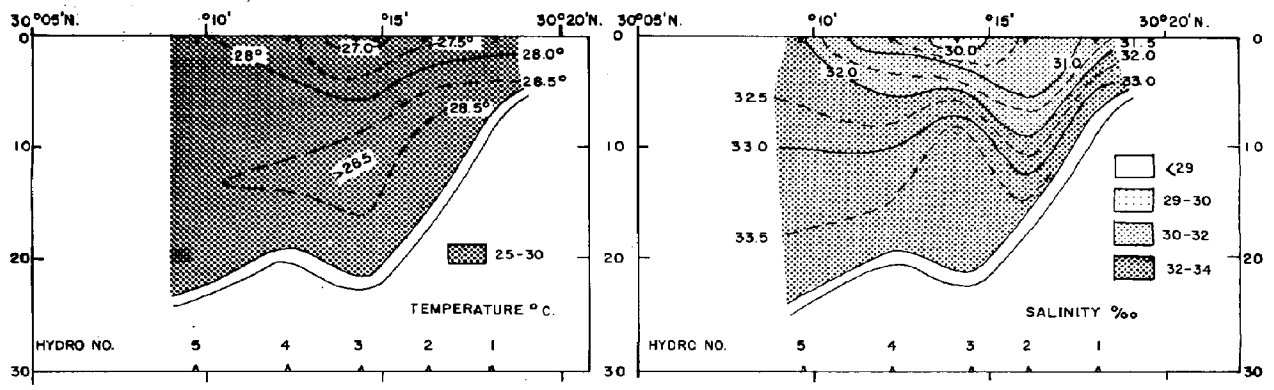
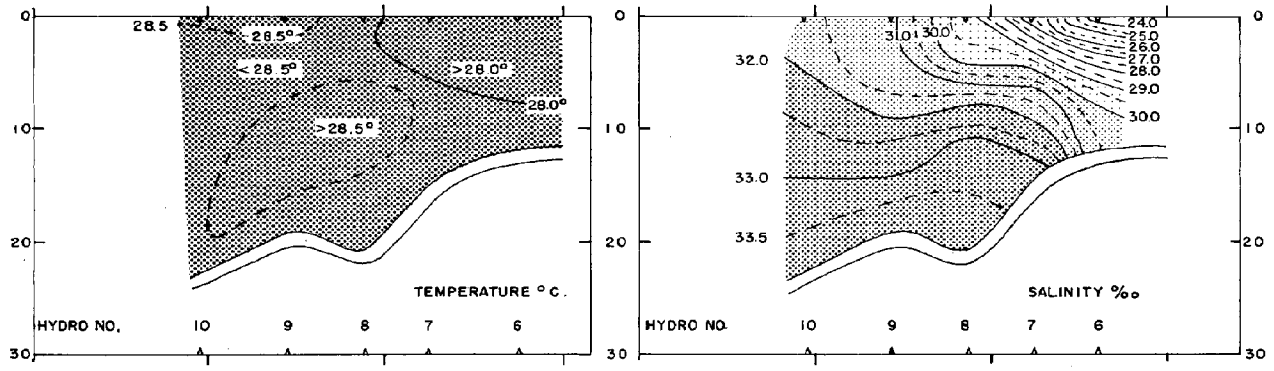


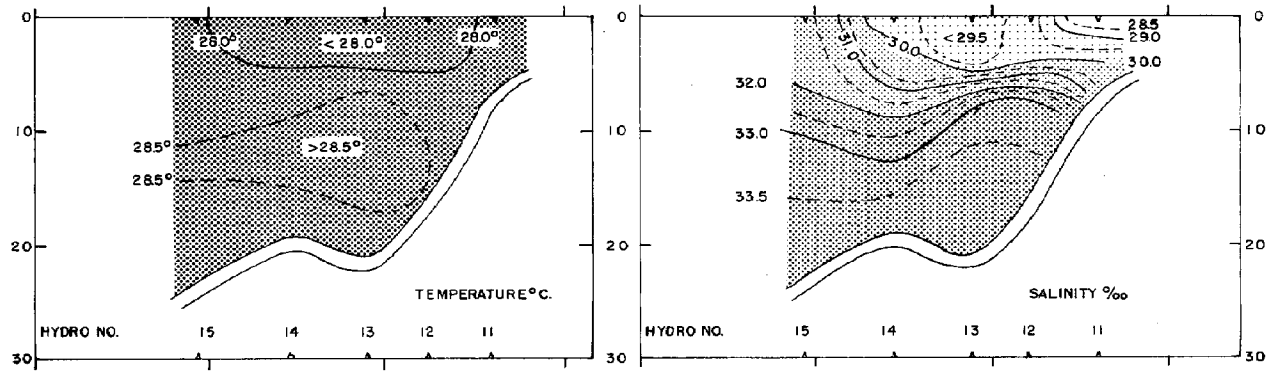
Figure 56 Pesticides at Surface ——— Bottom - - - - - -



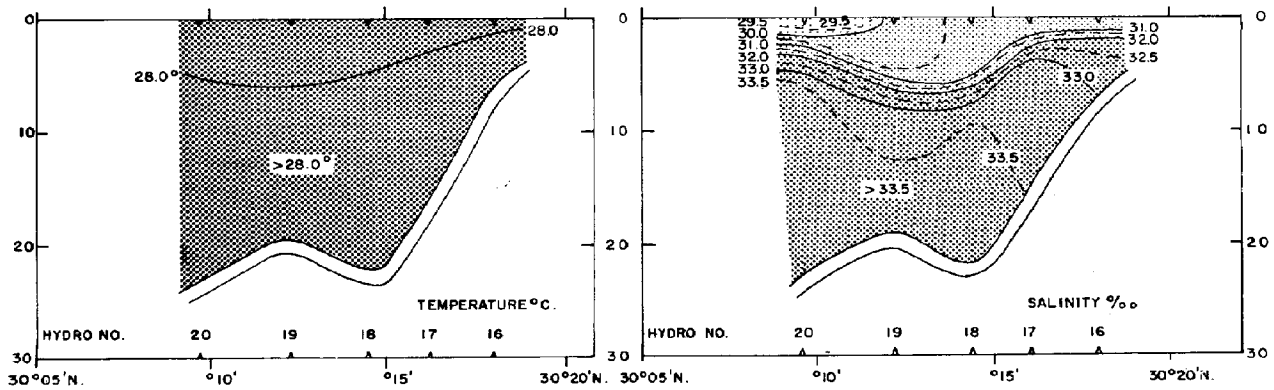
R/V TURSIOPS SUS-7126 1213-1626, September 14, 1971



R/V TURSIOPS SUS-7126 1810-2241 September 14, 1971

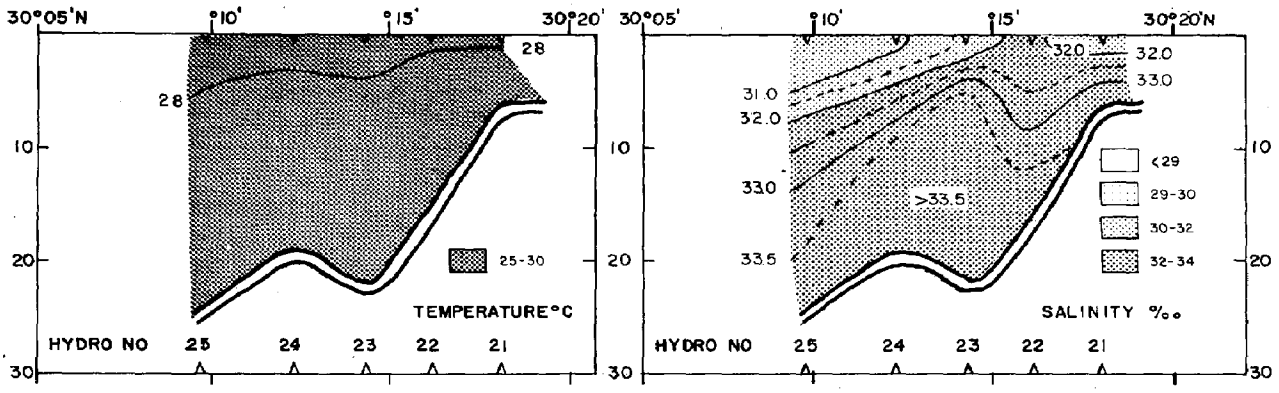


R/V TURSIOPS SUS-7126 0023-0455 September 15, 1971

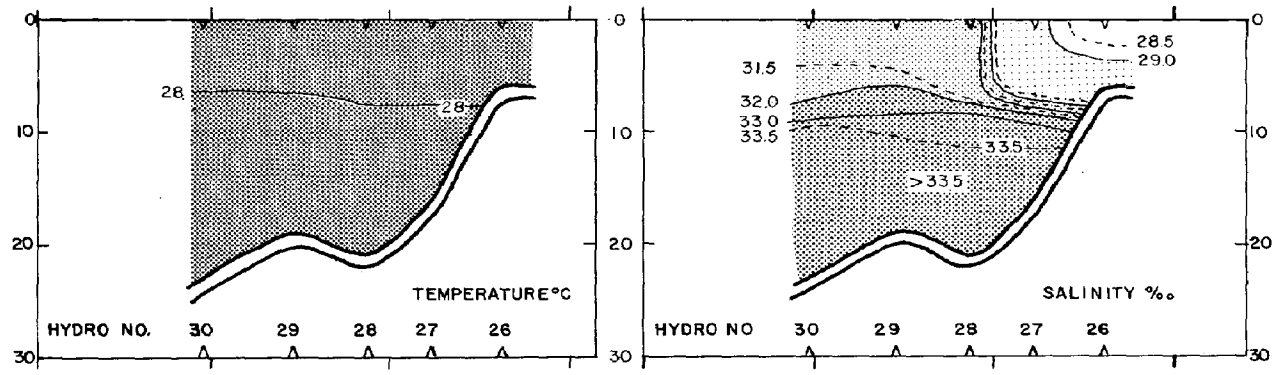


R/V TURSIOPS SUS-7126 0645-1111 September 15, 1971

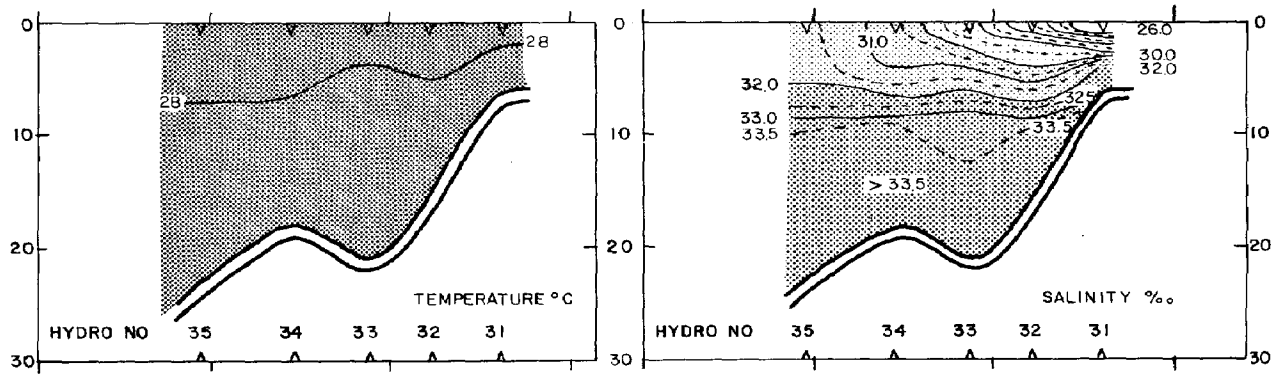
Figure 57 ESCAROSA I - Time Series Vertical Distribution Temperature and Salinity - 1213 GMT Sept. 14 to 1111 GMT Sept. 15, 1971



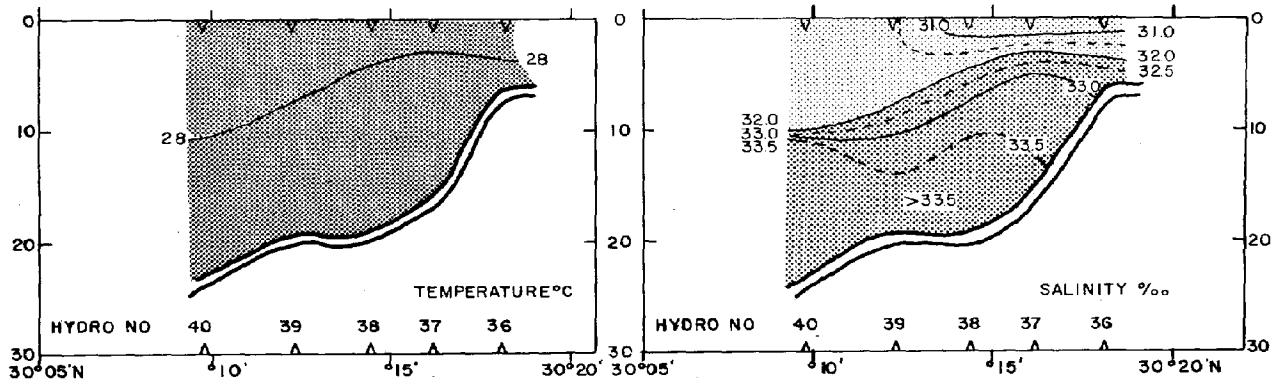
R/V TURSIOPS SUS-7126 1303-1727, September 15, 1971



R/V TURSIOPS SUS-7126 1915-2340, September 15, 1971



R/V TURSIOPS SUS-7126 0130-0605, September 16, 1971



R/V TURSIOPS SUS-7126 0745-1228, September 16, 1971

Figure 58 ESCAROSA I – Time Series Vertical Distribution Temperature and Salinity – 1303 GMT Sept. 15 to 1228 GMT Sept. 16, 1971

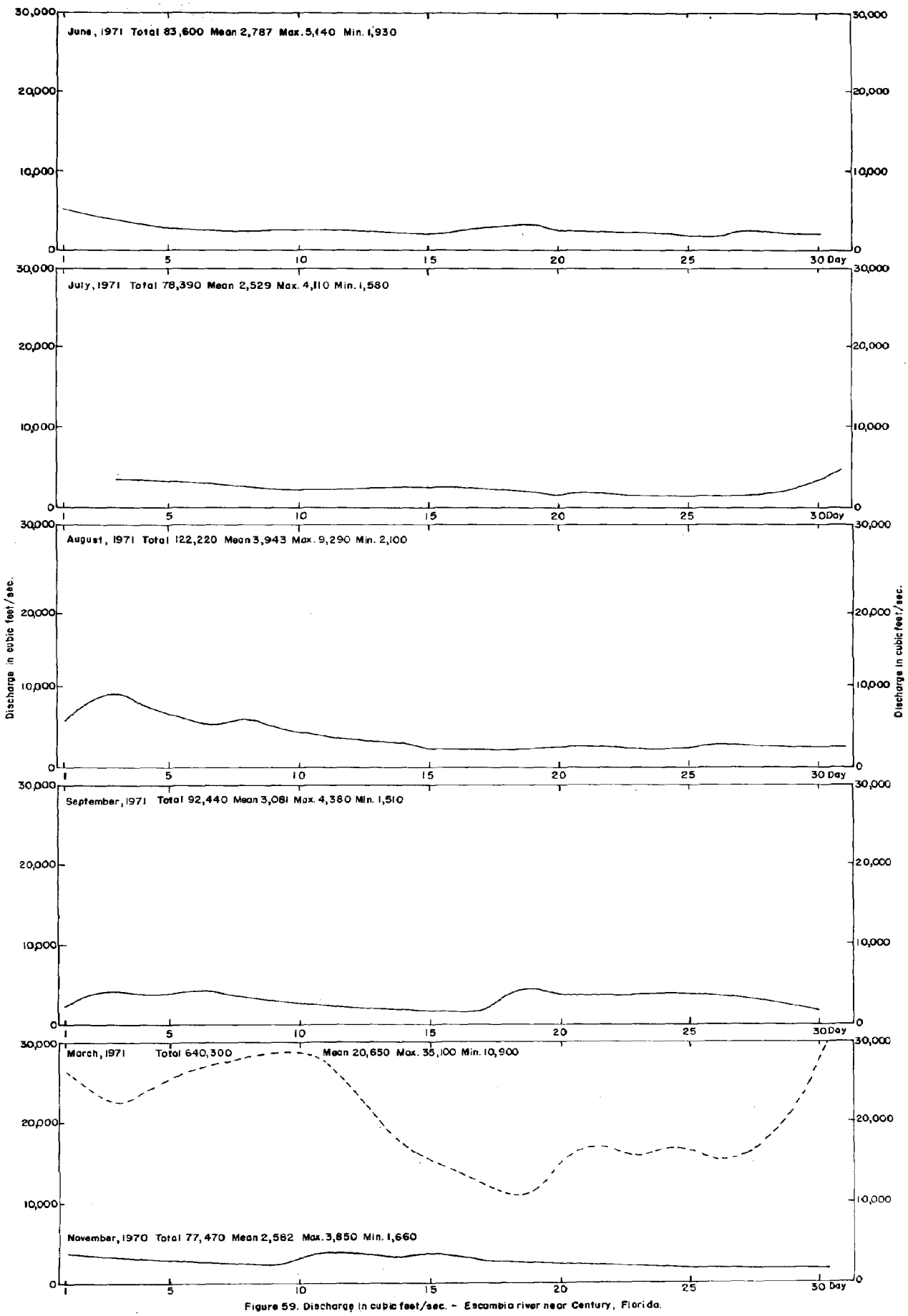


Figure 59. Discharge in cubic feet/sec. - Escambia river near Century, Florida.

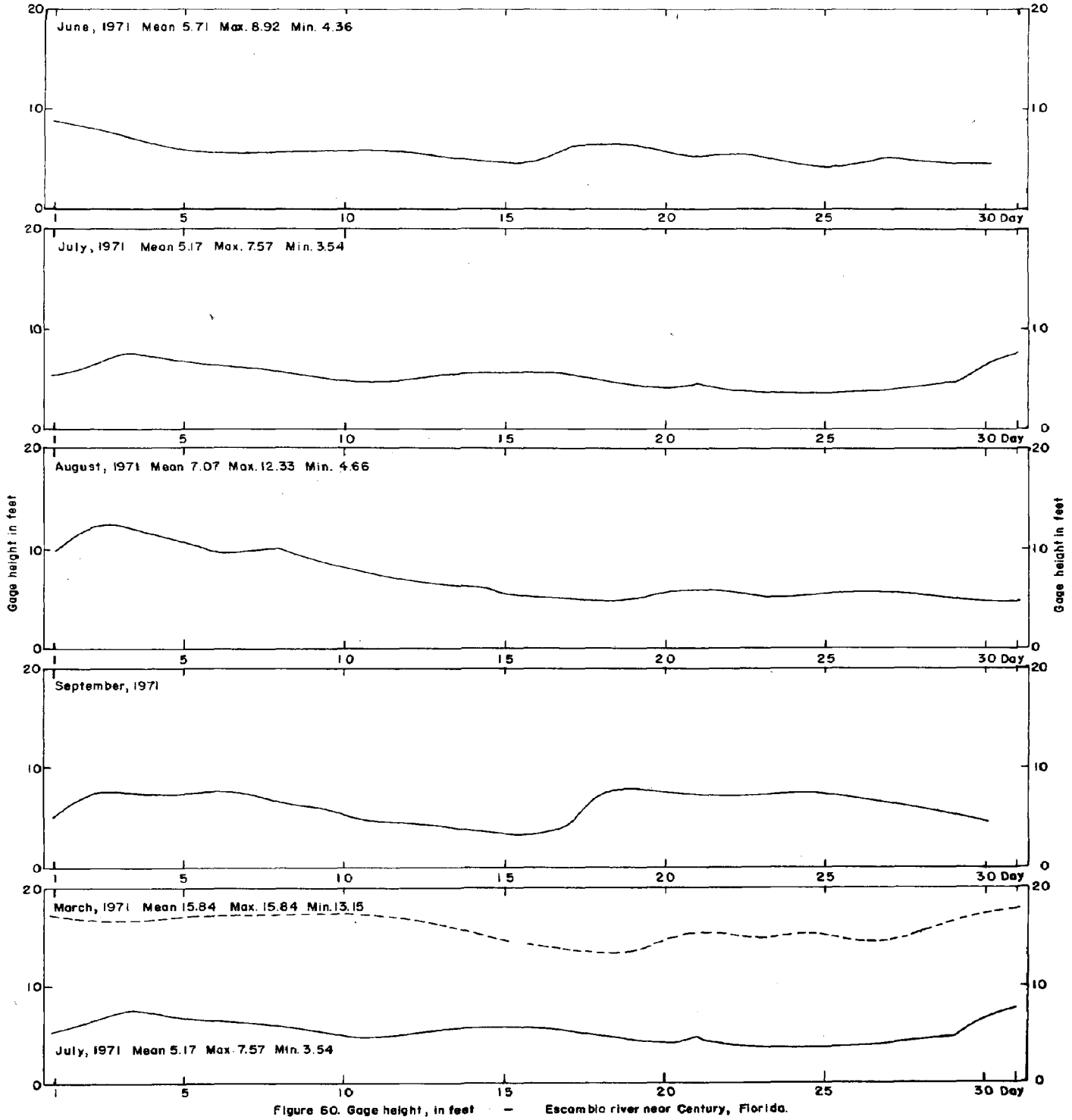


Figure 60. Gage height, in feet — Escambia river near Century, Florida.

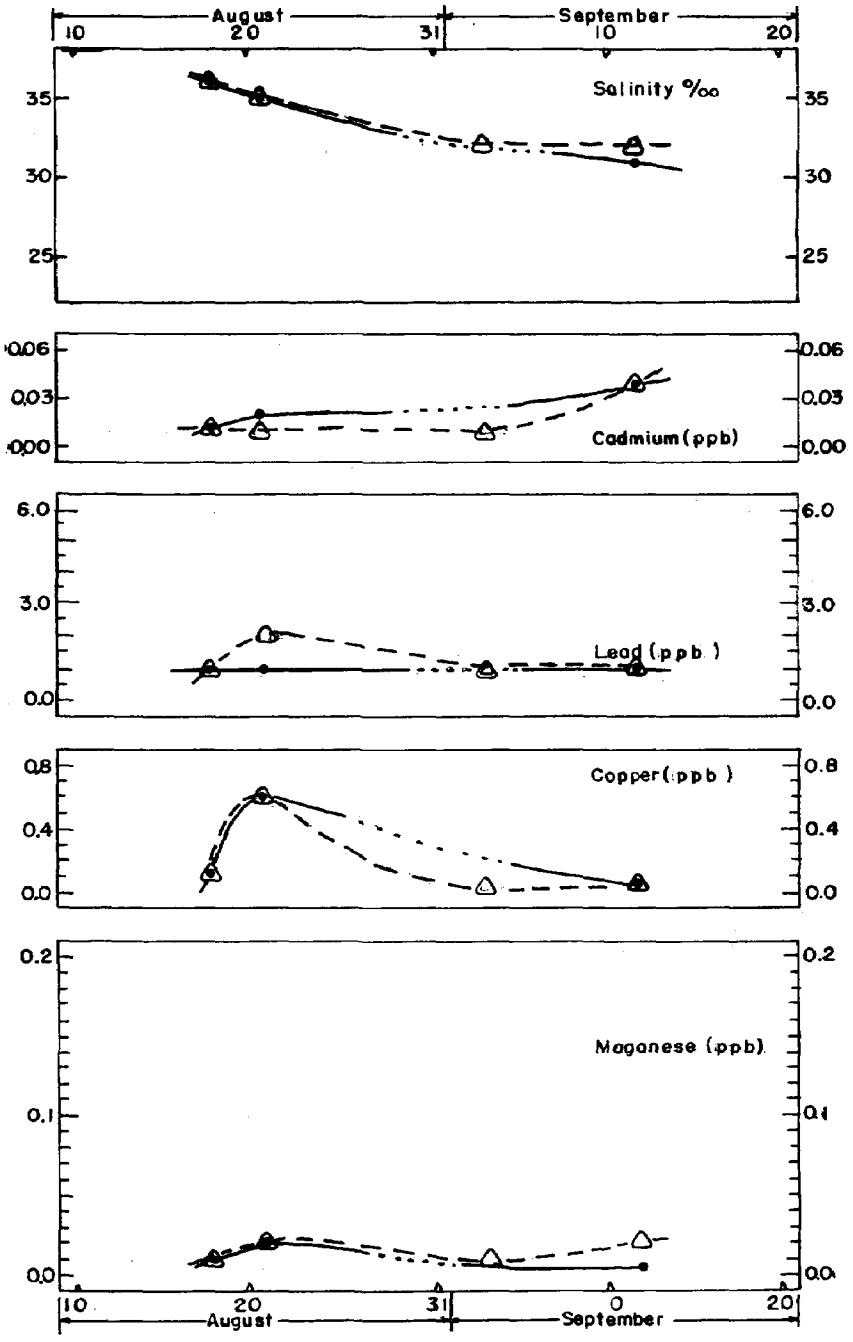


Figure 61. Salinity, Cadmium, Lead, Copper and Manganese at Station N-14 entrance to Pensacola Bay August 13 - September 12, 1971 ● Surface and △ Bottom values

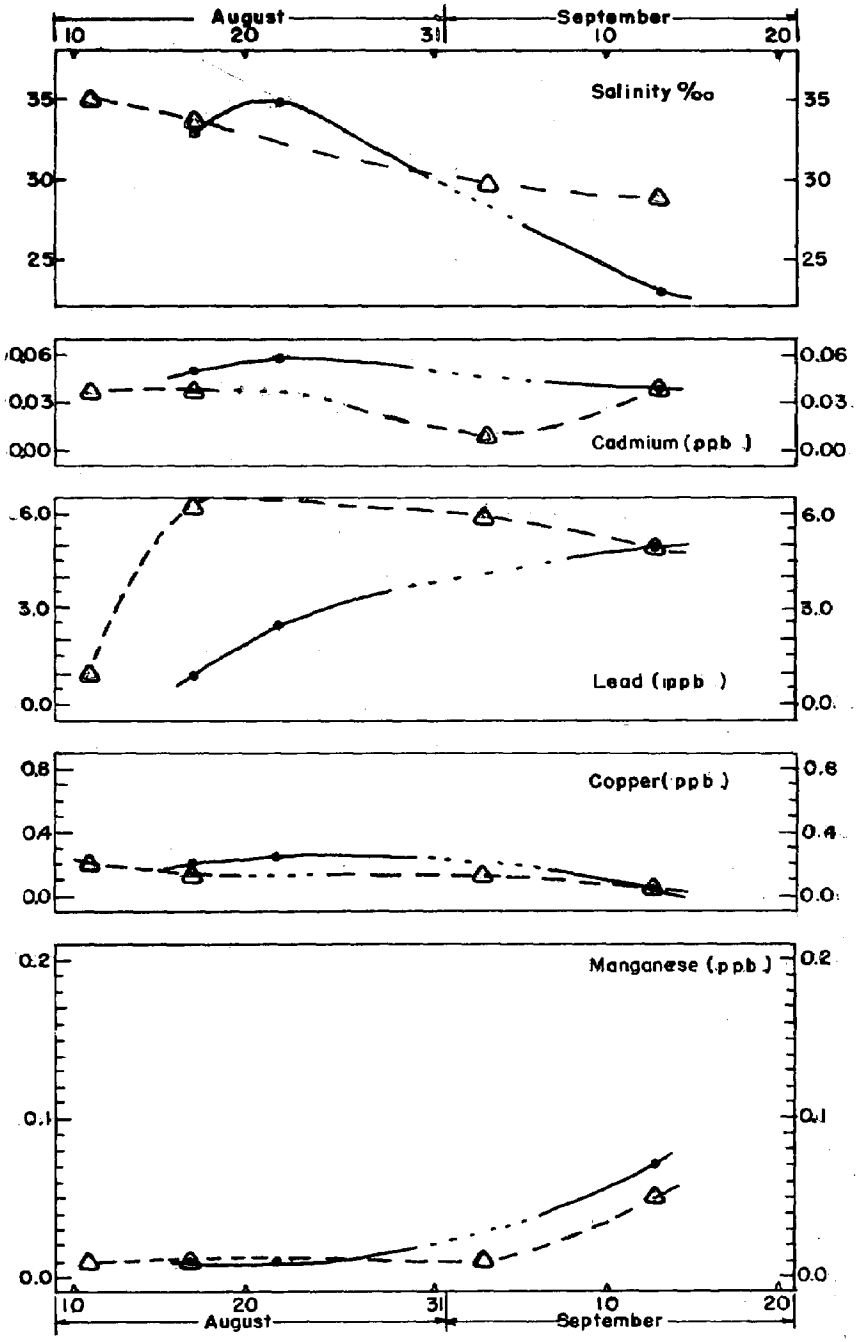


Figure 62. Salinity, Cadmium, Lead, Copper and Manganese at Station L-42 entrance to Perdido Bay August 17 - September 13, 1971 • Surface and △ Bottom values

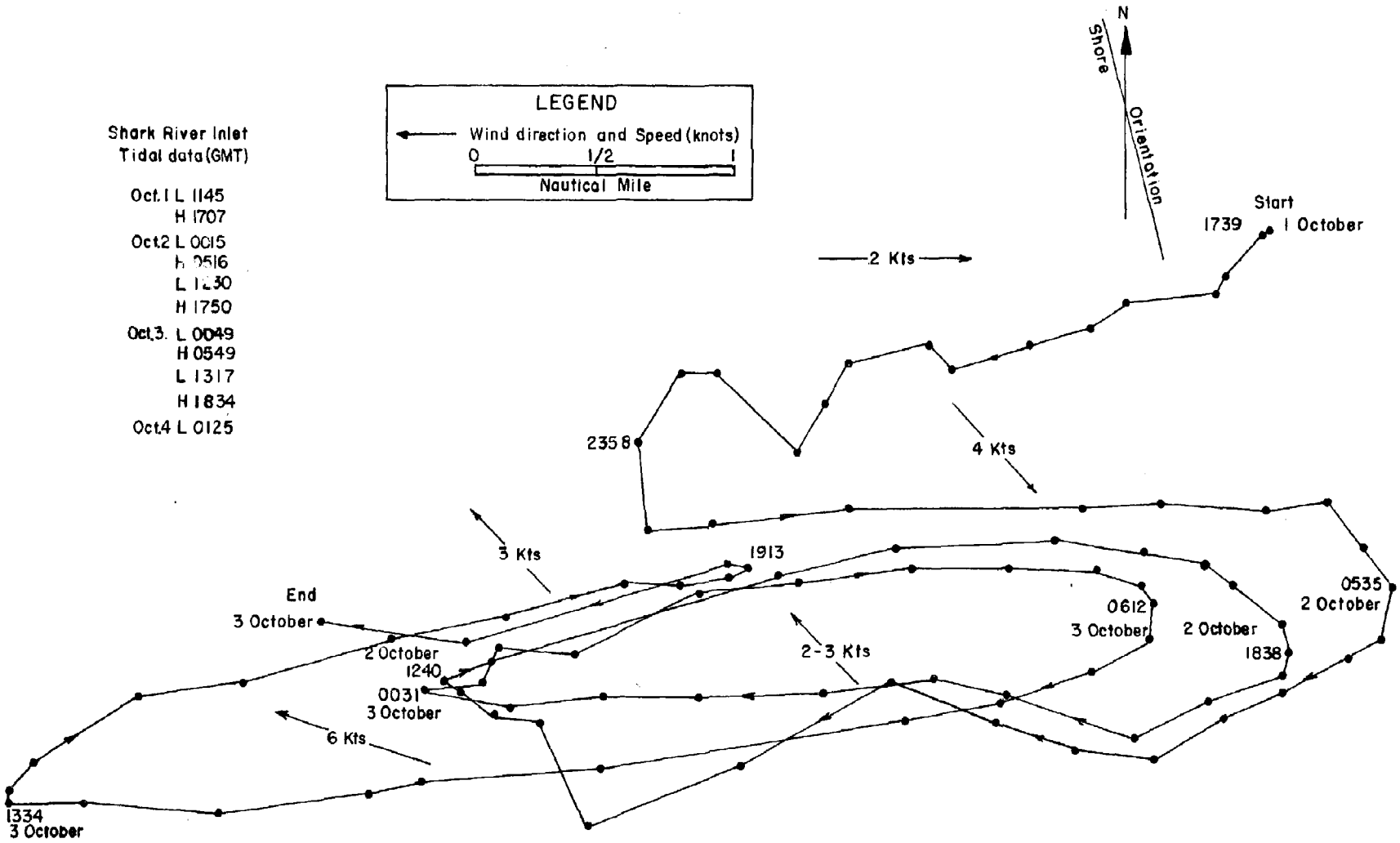


Figure 63. Subsurface current drogue (depth 2 meters) at station SR off Shark River on October 1-3, 1959. Drogue movement is indicated by arrows on lines connecting observation points. Times (GMT) of high and low waters for Shark River inlet 11.5 miles to east are in upper left corner. Prevailing wind and average wind speed are indicated along applicable sections of the track. Depth to bottom 7 meters. (from Rinkel and Dunlop, 1961).

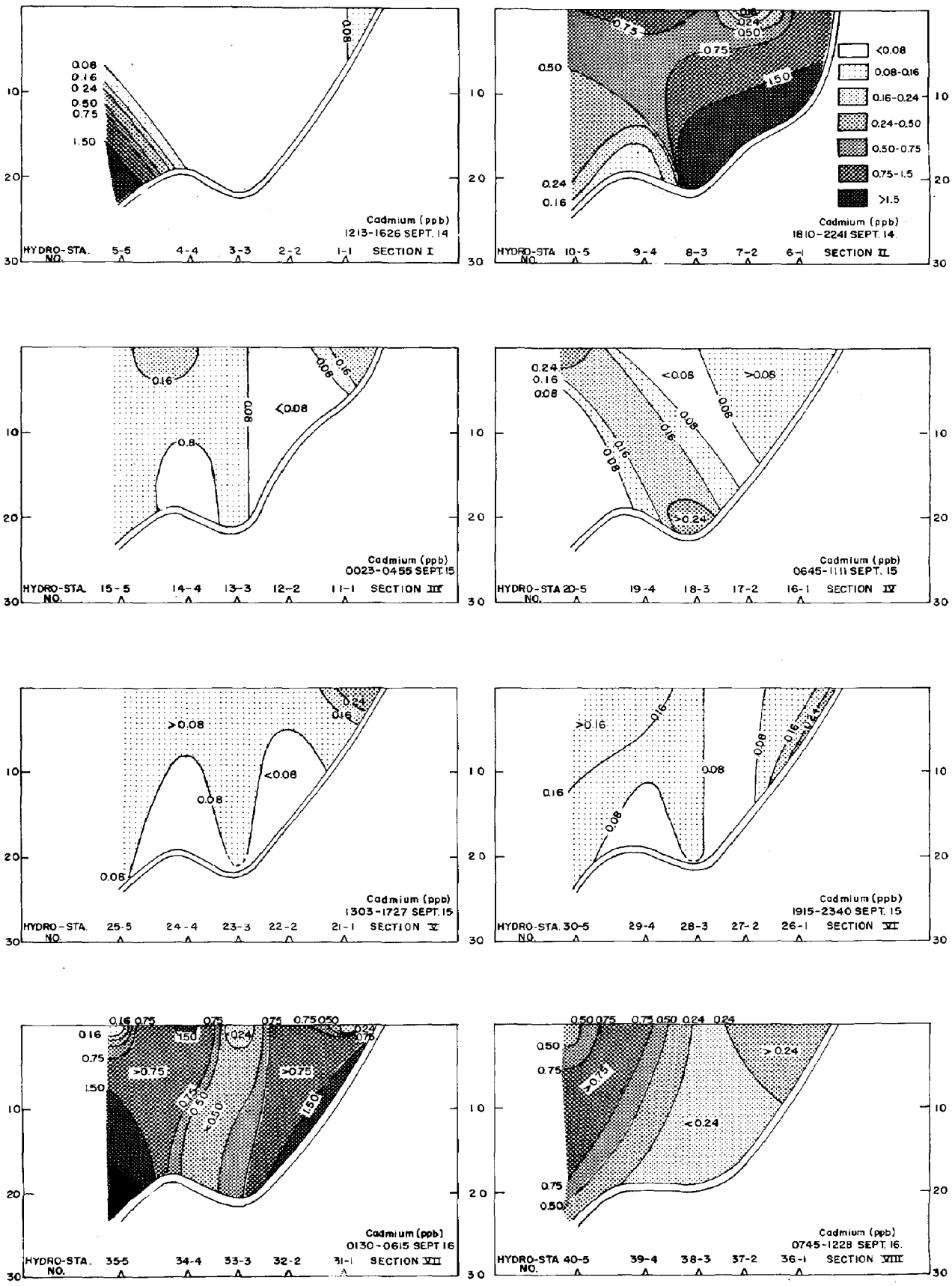


Figure 64 ESCAROSA I Time Series - R/V TURSIOPS - Vertical Distribution of Cadmium (ppb) - September 14-16, 1971

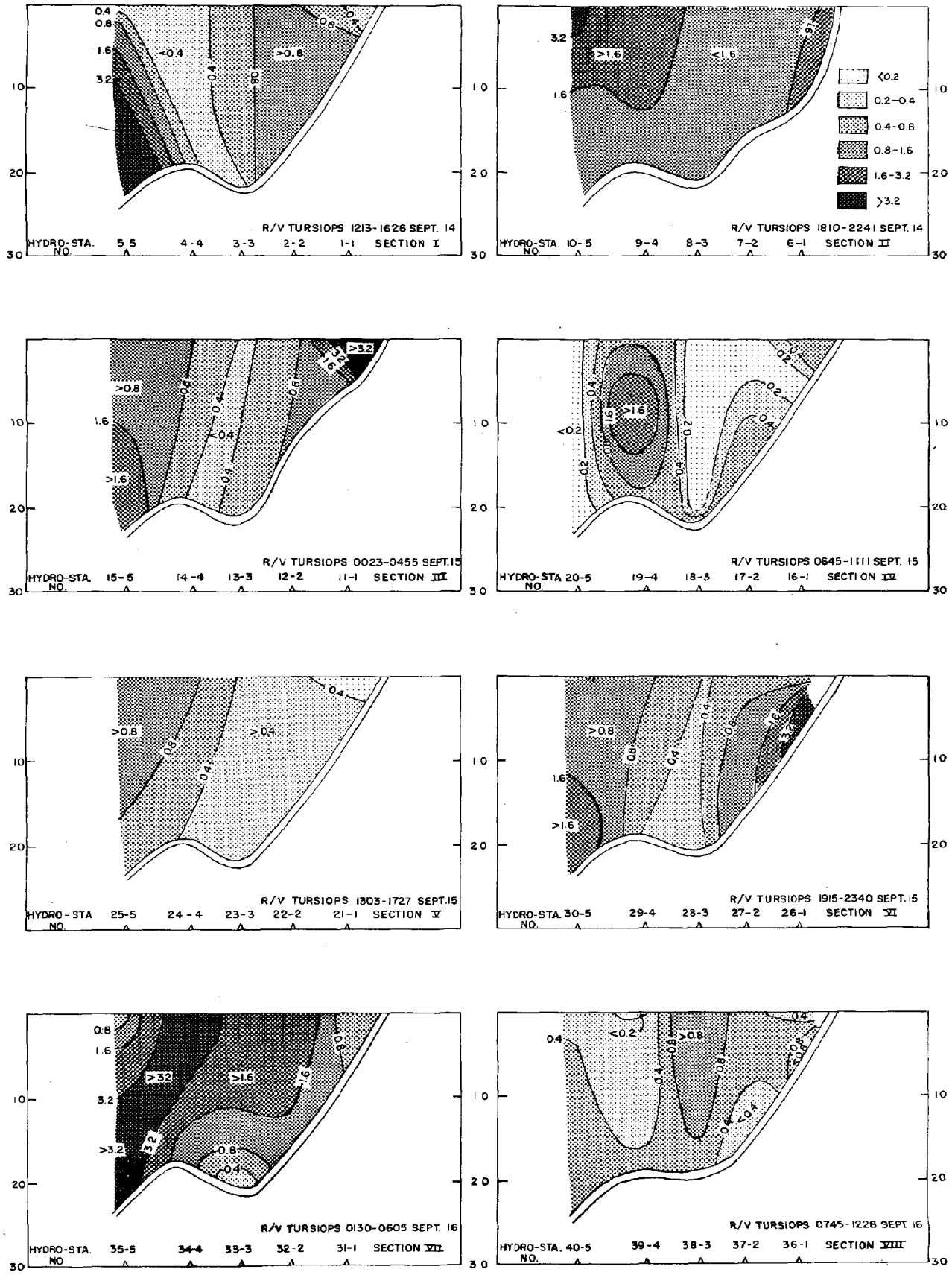


Figure 65 ESCAROSA-I Time Series - R/V TURSIOPS - Vertical Distribution of Lead (ppb) - September 14-16, 1971

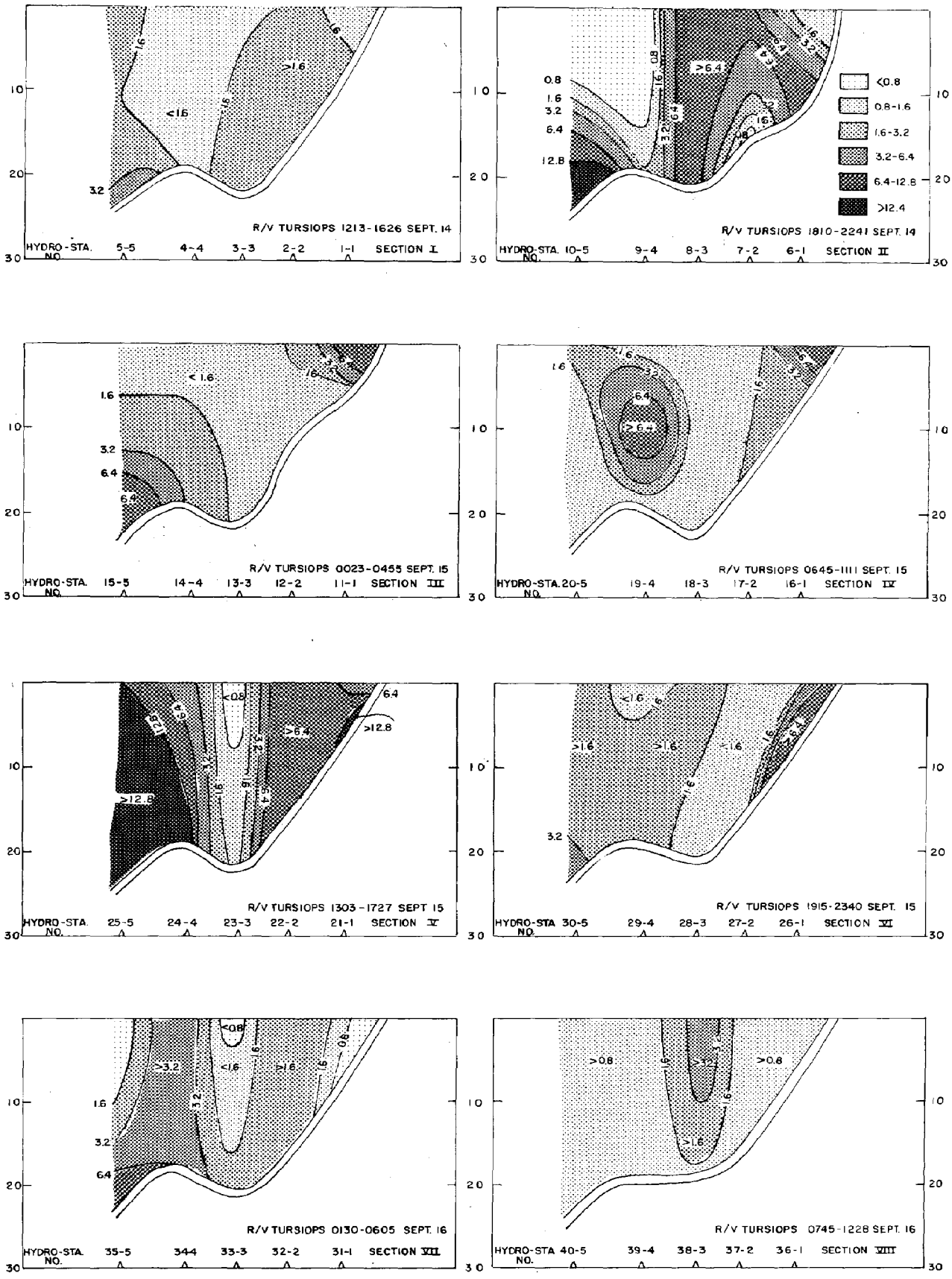


Figure 66 ESCAROSA-I - Time Series R/V TURSIOPS - Vertical Distribution of Copper (ppb) - September 14-16, 1971

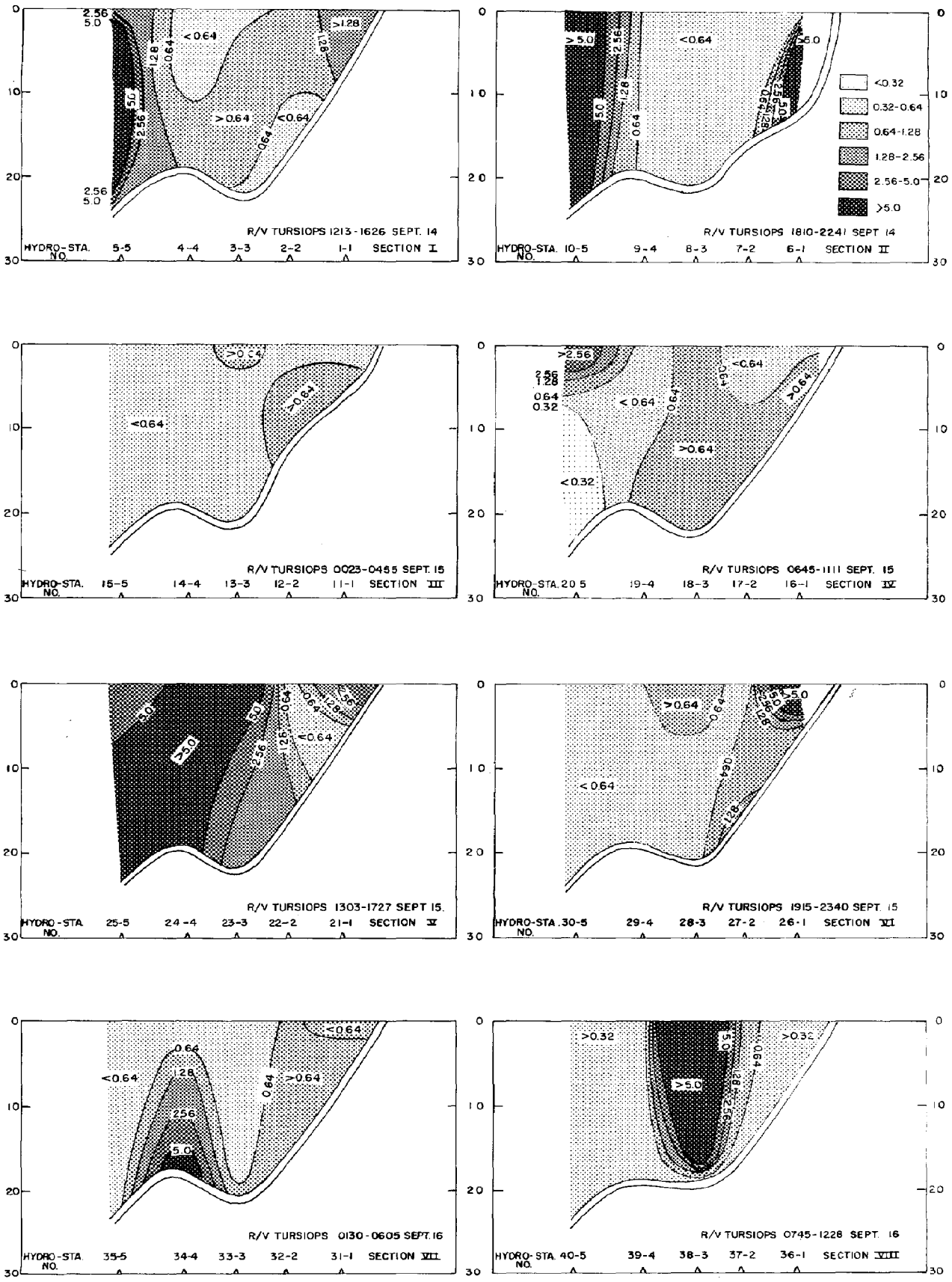


Figure67ESCAROSA-I- Time Series R/V TURSIOPS – Vertical Distribution of Chromium(ppb) September 14-16, 1971

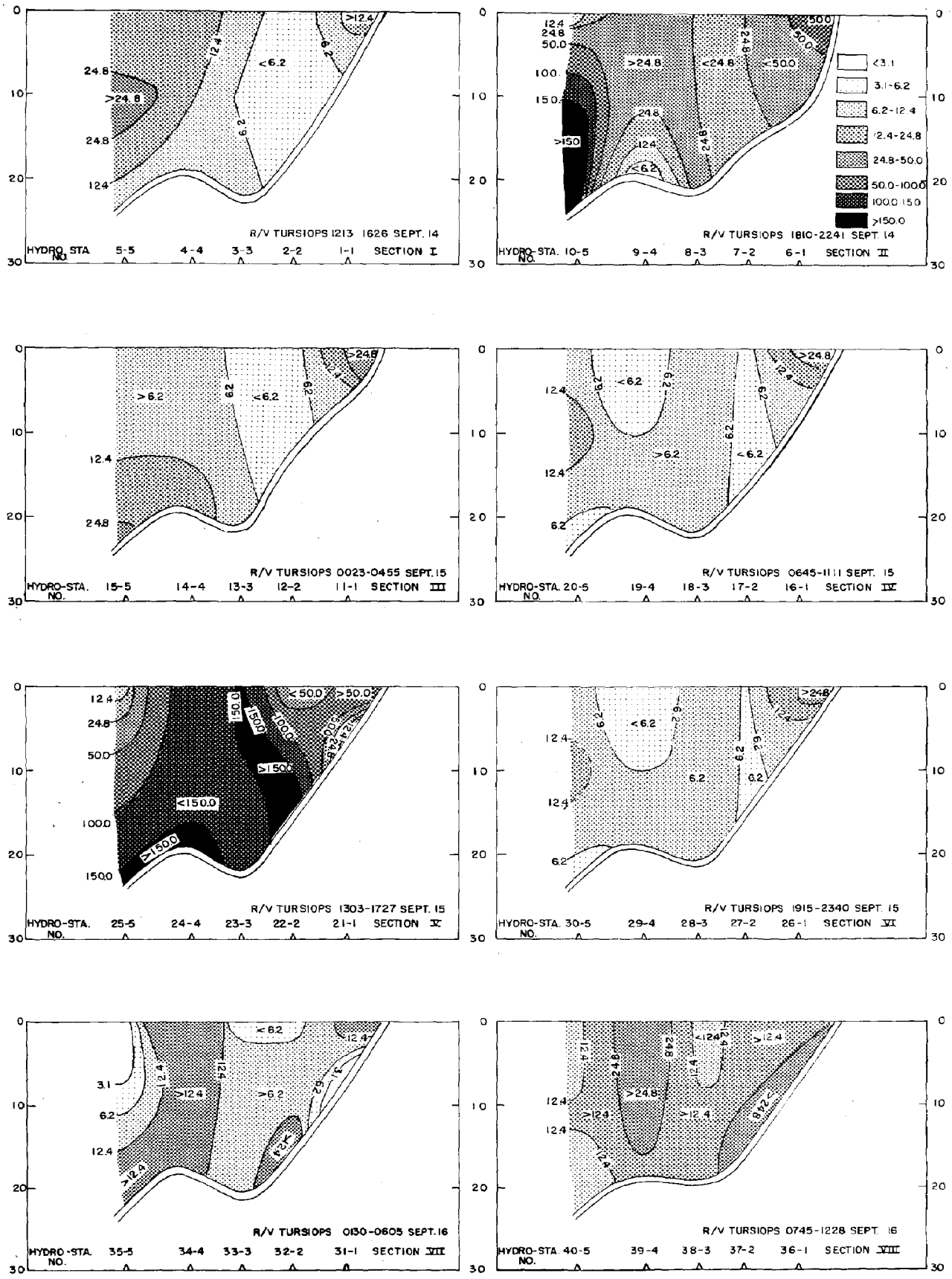


Figure 68 ESCAROSA-I-Time Series R/V TURSIOPS - Vertical Distribution Zinc (ppb) September 14-16, 1971

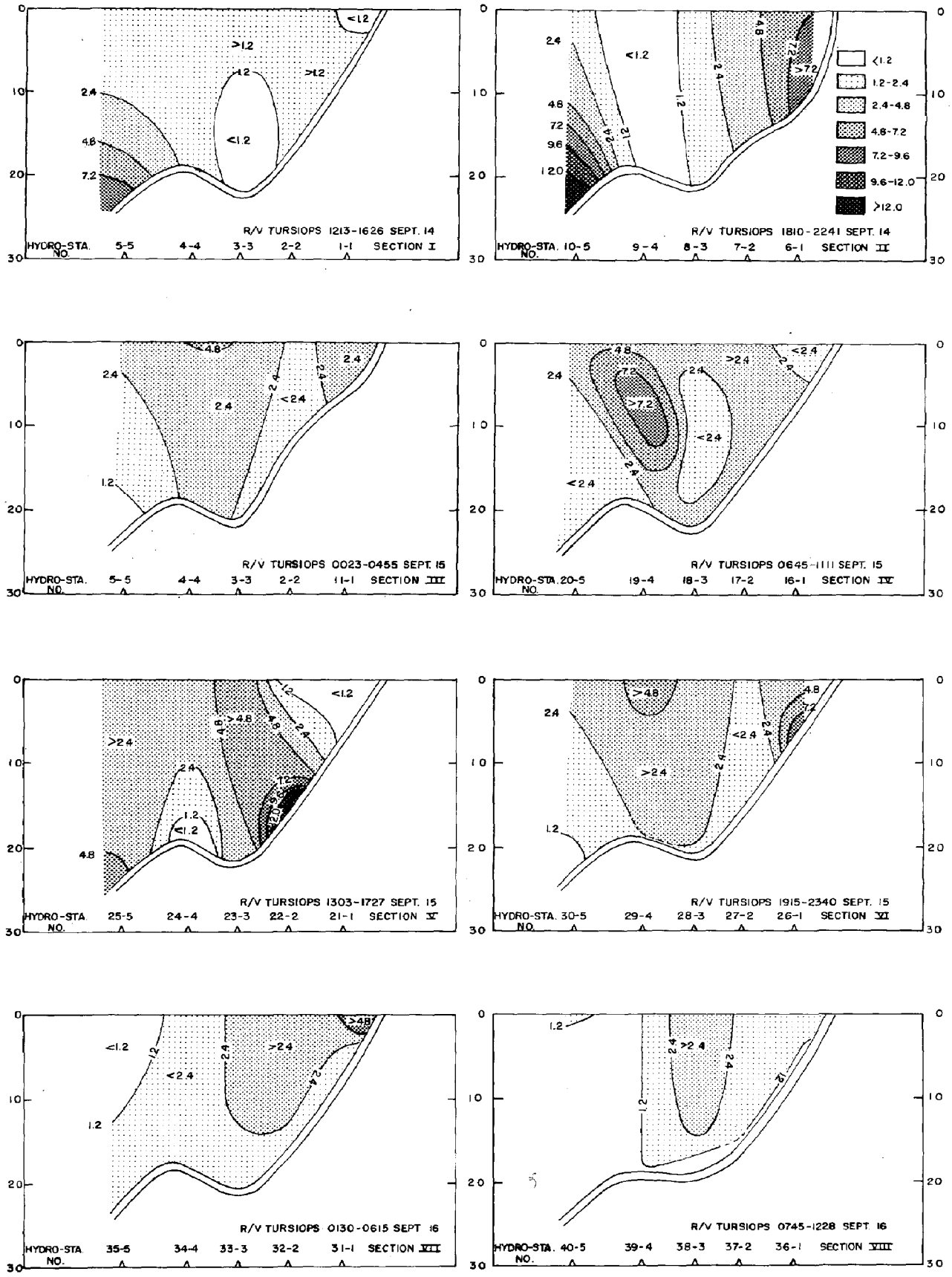


Figure 69 ESCAROSA-I- Time Series R/V TURSIOPS - Vertical Distribution of Manganese (ppb) September 14-16, 1971

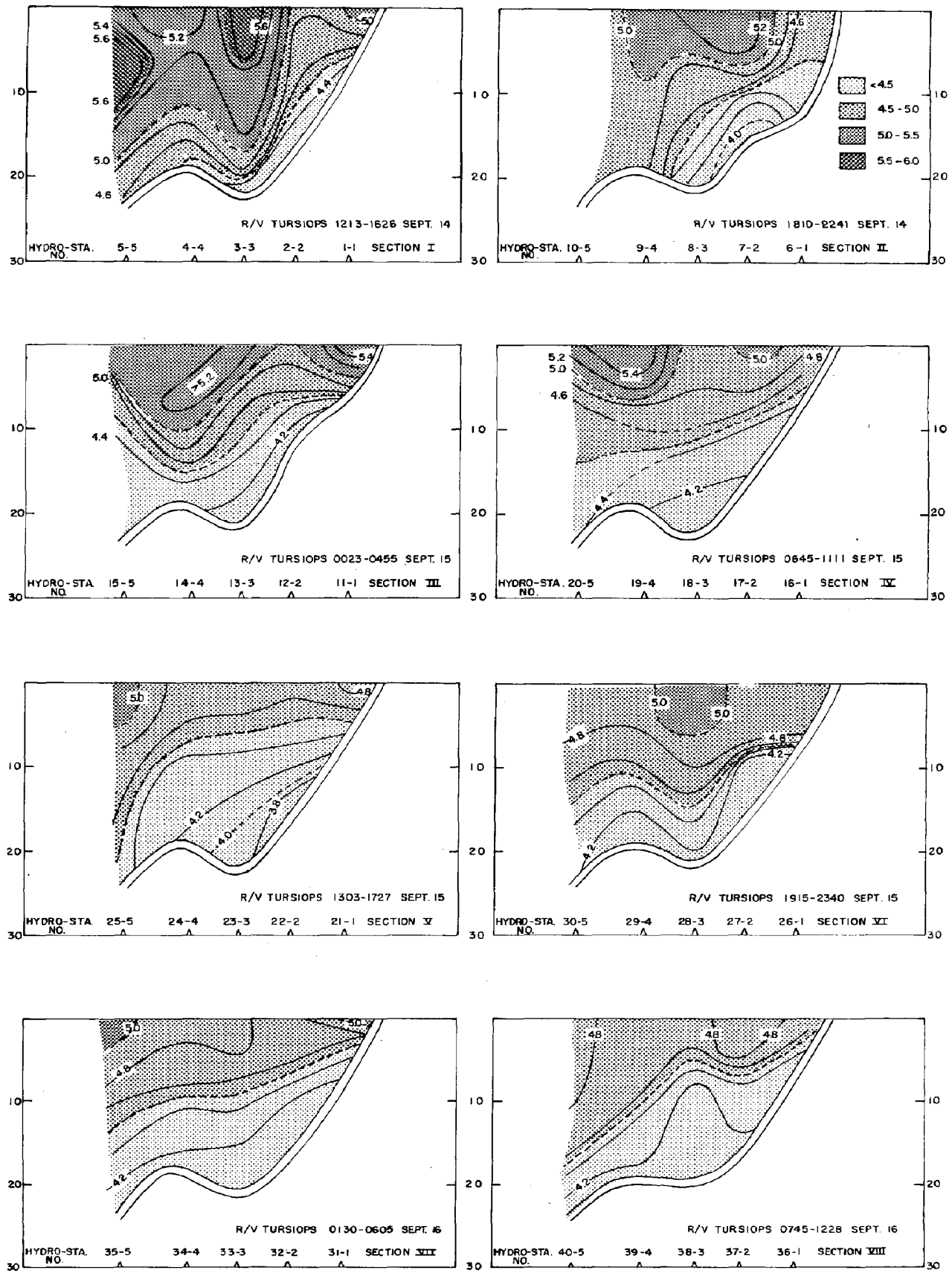


Figure 70 ESCAROSA-I Time Series - R/V TURSIOPS - Vertical Distribution of Oxygen ml/L - September 14-16, 1971

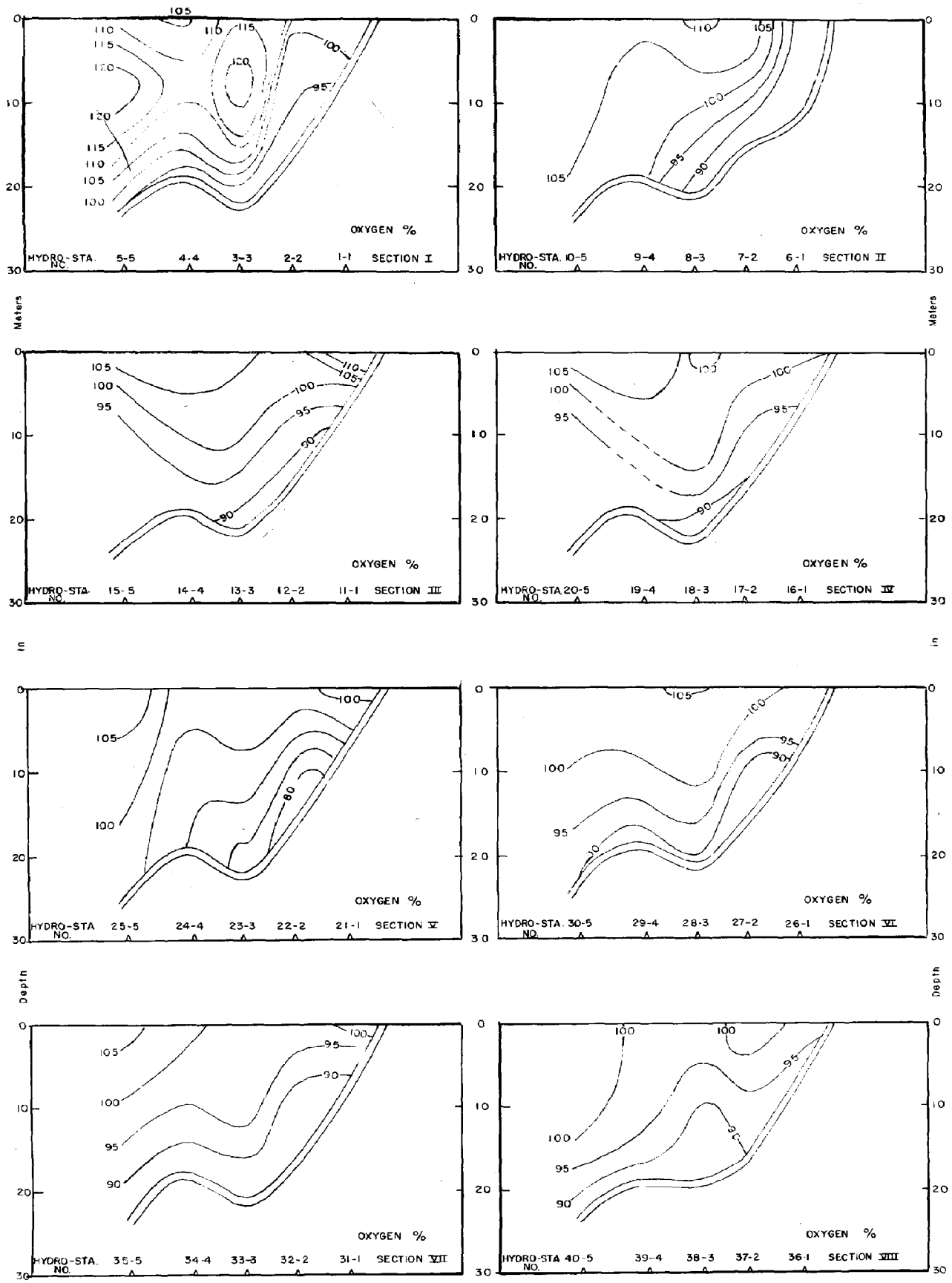


Figure 71 Vertical distribution of oxygen saturation September 14 - 16, 1971.

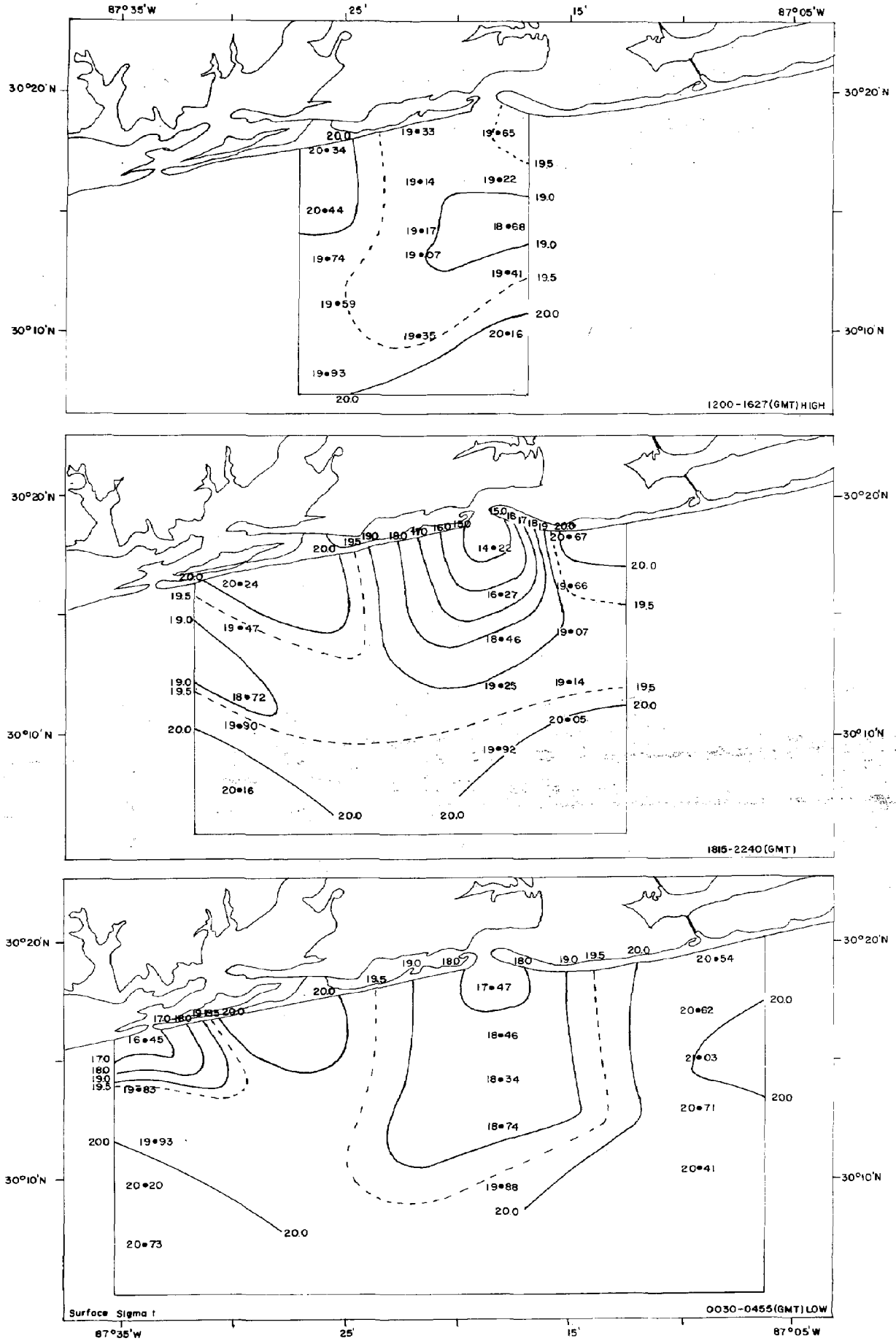


Figure 72 Surface Sigma t - Distribution between high and low tide at Pensacola, 1200 GMT, September 14 to 0455 GMT, September 15, 1971

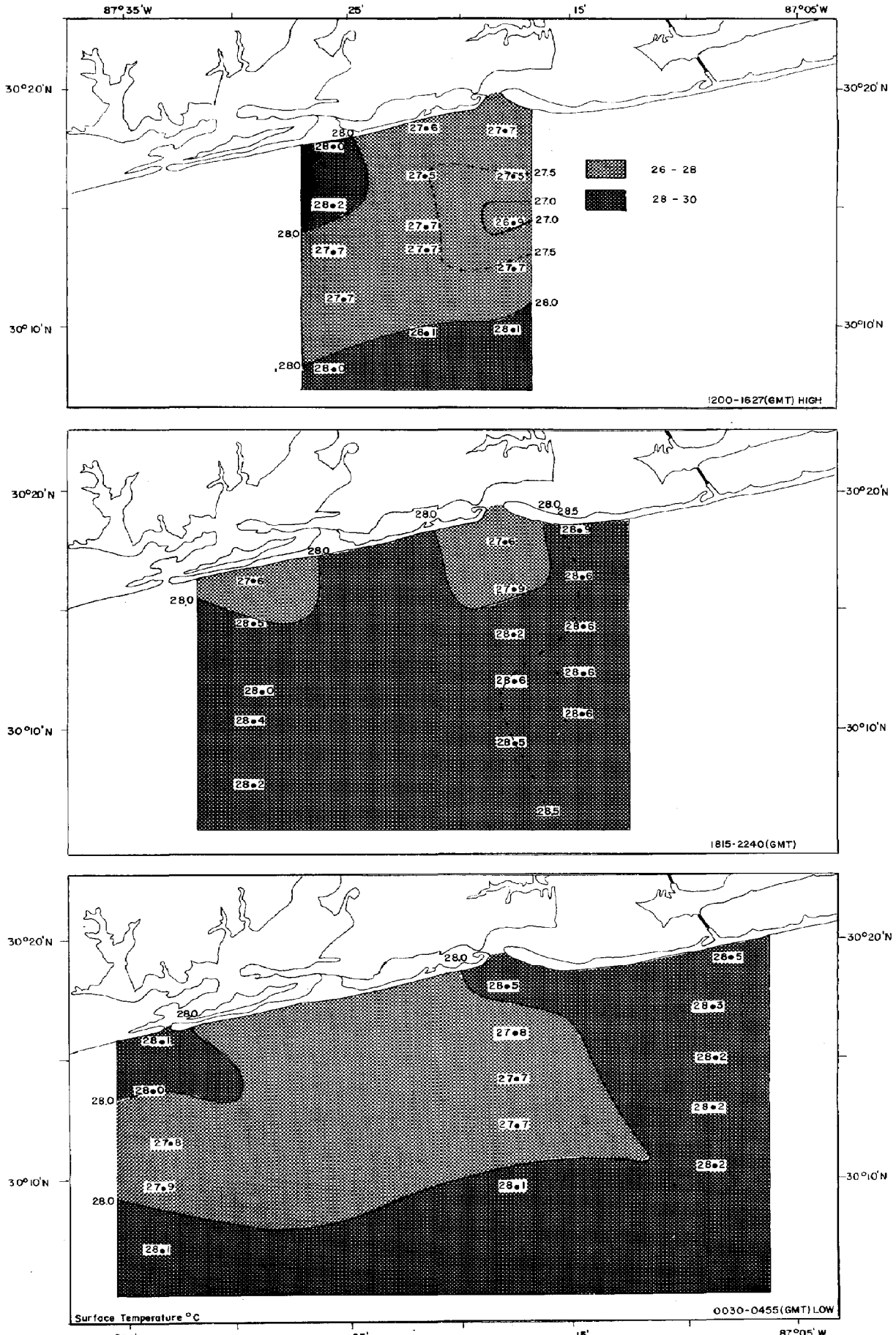


Figure 73. Surface Temperature-Distribution between high and low tide Pensacola, 1200 GMT, September 14 to 0455 GMT, September 15, 1971

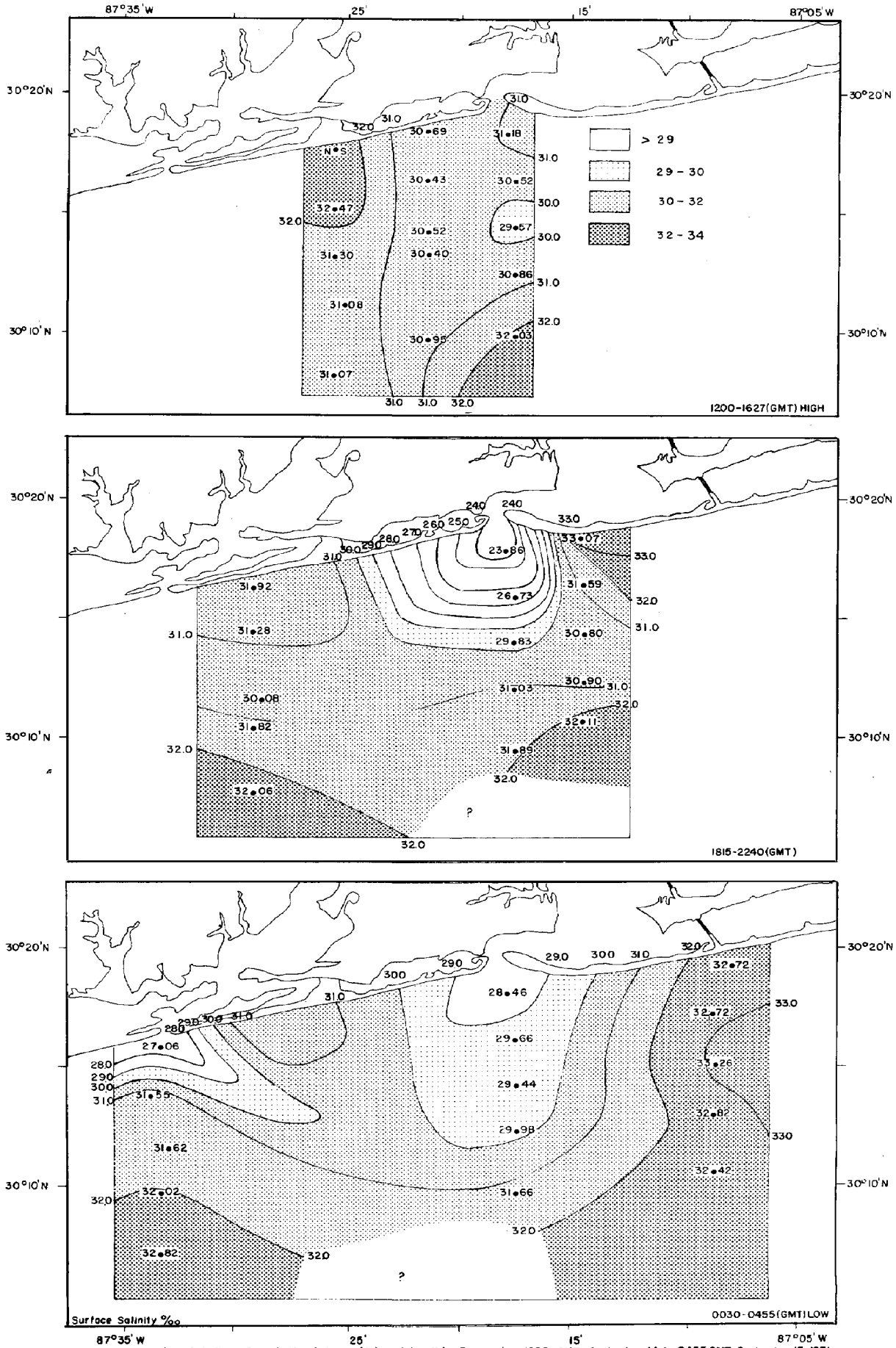


Figure 74 Surface Salinity - Distribution between high and low tide Pensacola, 1200 GMT, September 14 to 0455 GMT, September 15, 1971

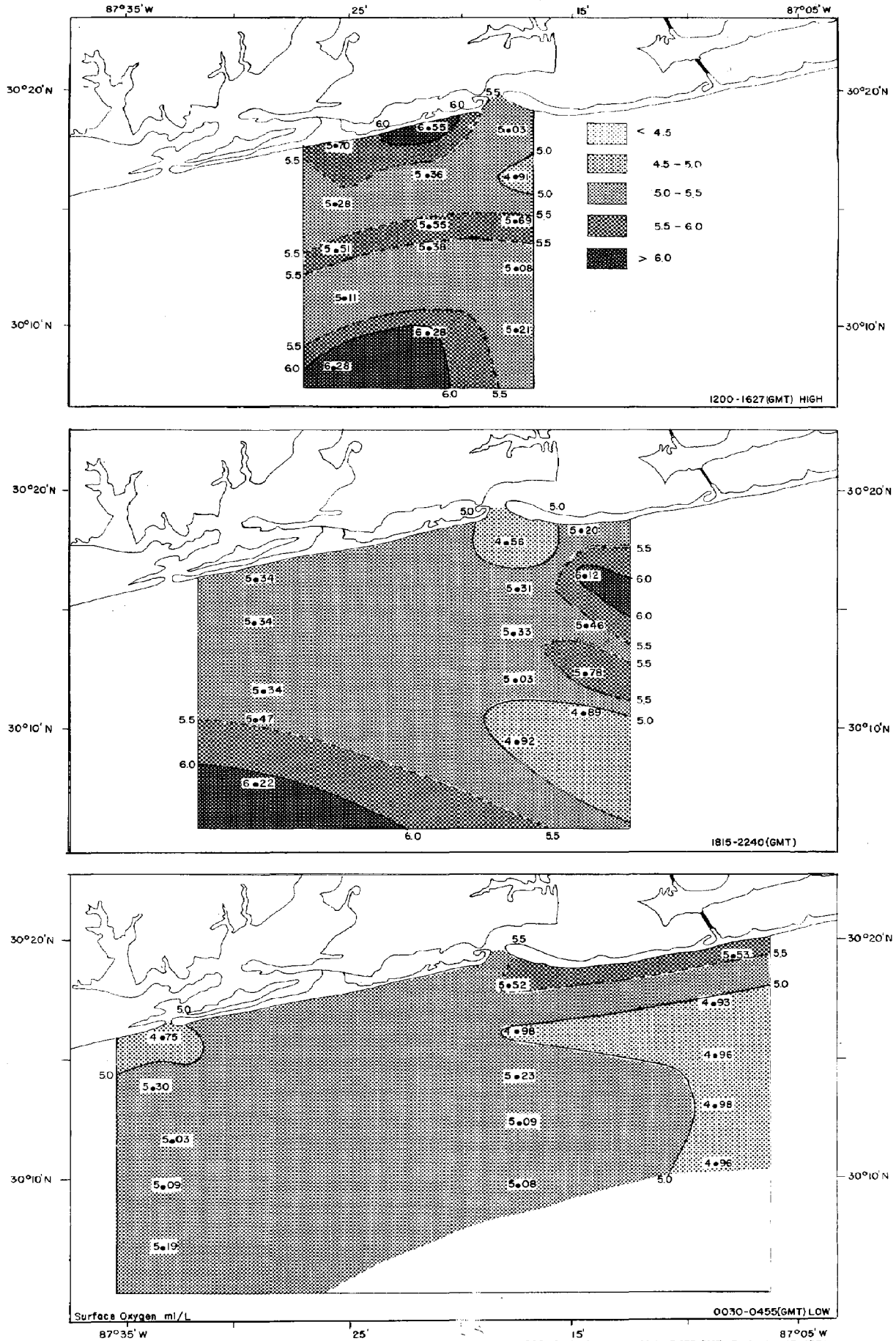


Figure 75 Surface Oxygen - Distribution between high and low tide ...acola, 1200 GMT, September 14 to 0455 GMT, September 15, 1971

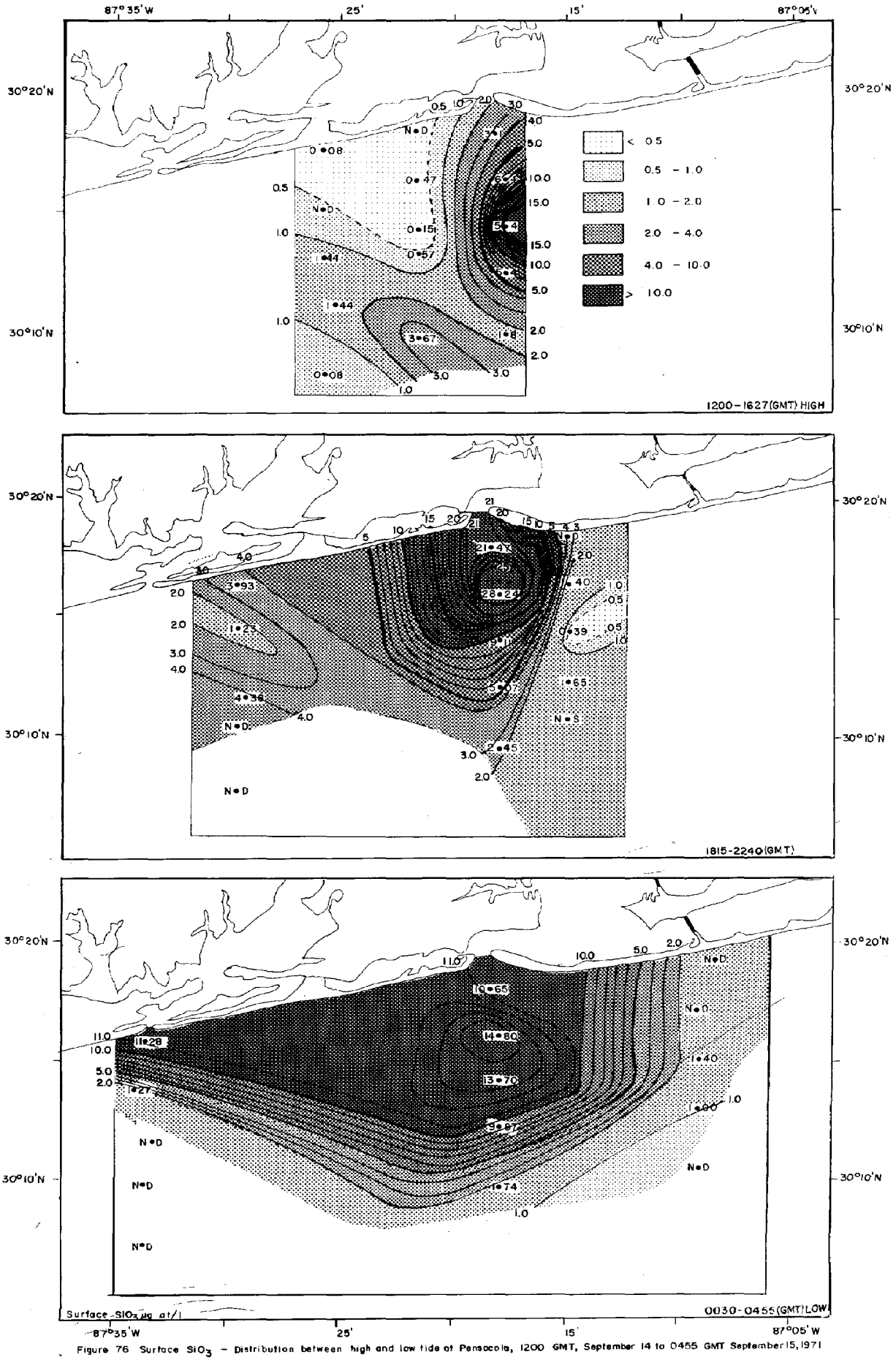


Figure 76 Surface SiO_3 – Distribution between high and low tide at Pensacola, 1200 GMT, September 14 to 0455 GMT September 15, 1971

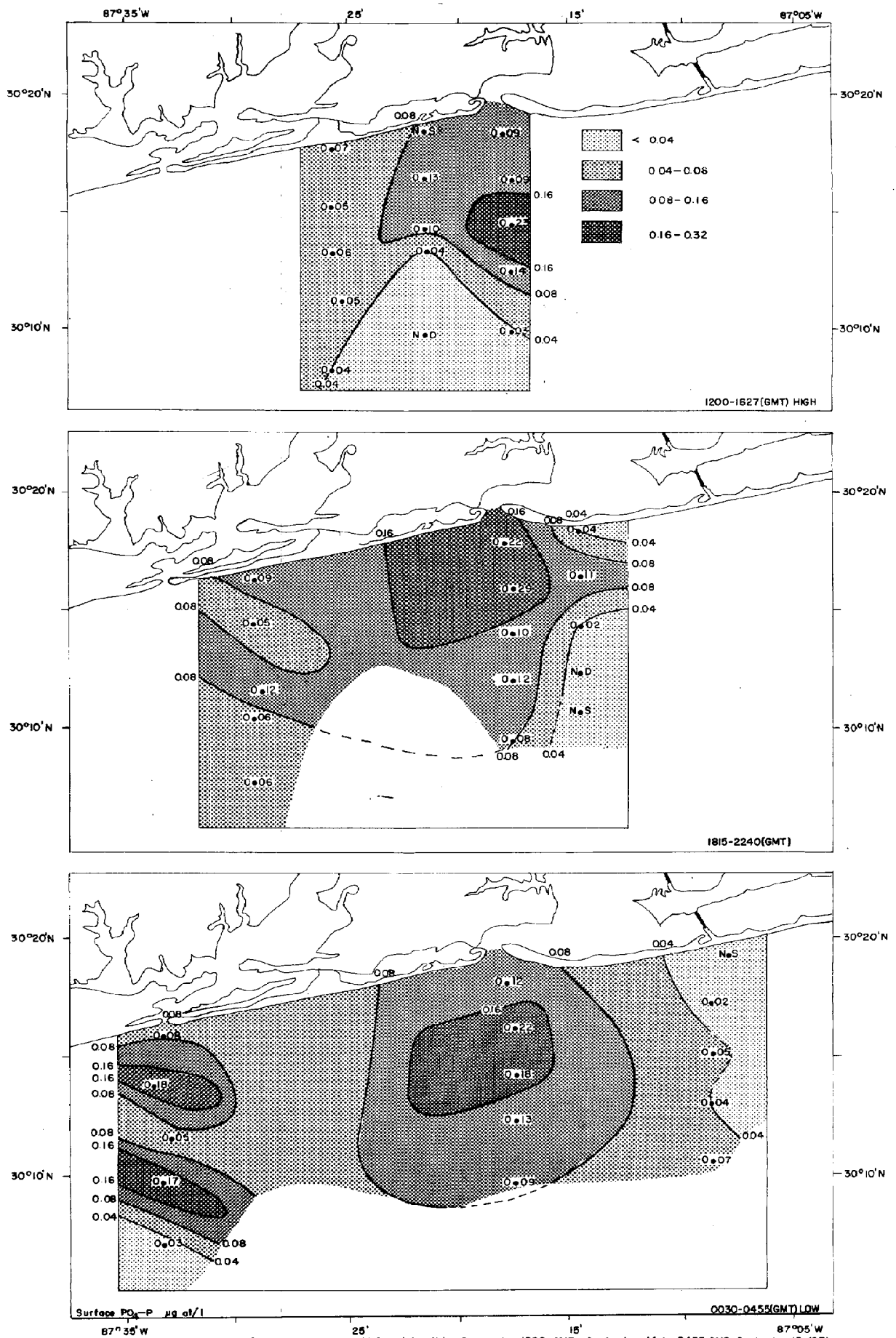


Figure 77 Surface PO_4-P - Distribution between high and low tide Pensacola, 1200 GMT, September 14 to 0455 GMT, September 15, 1971

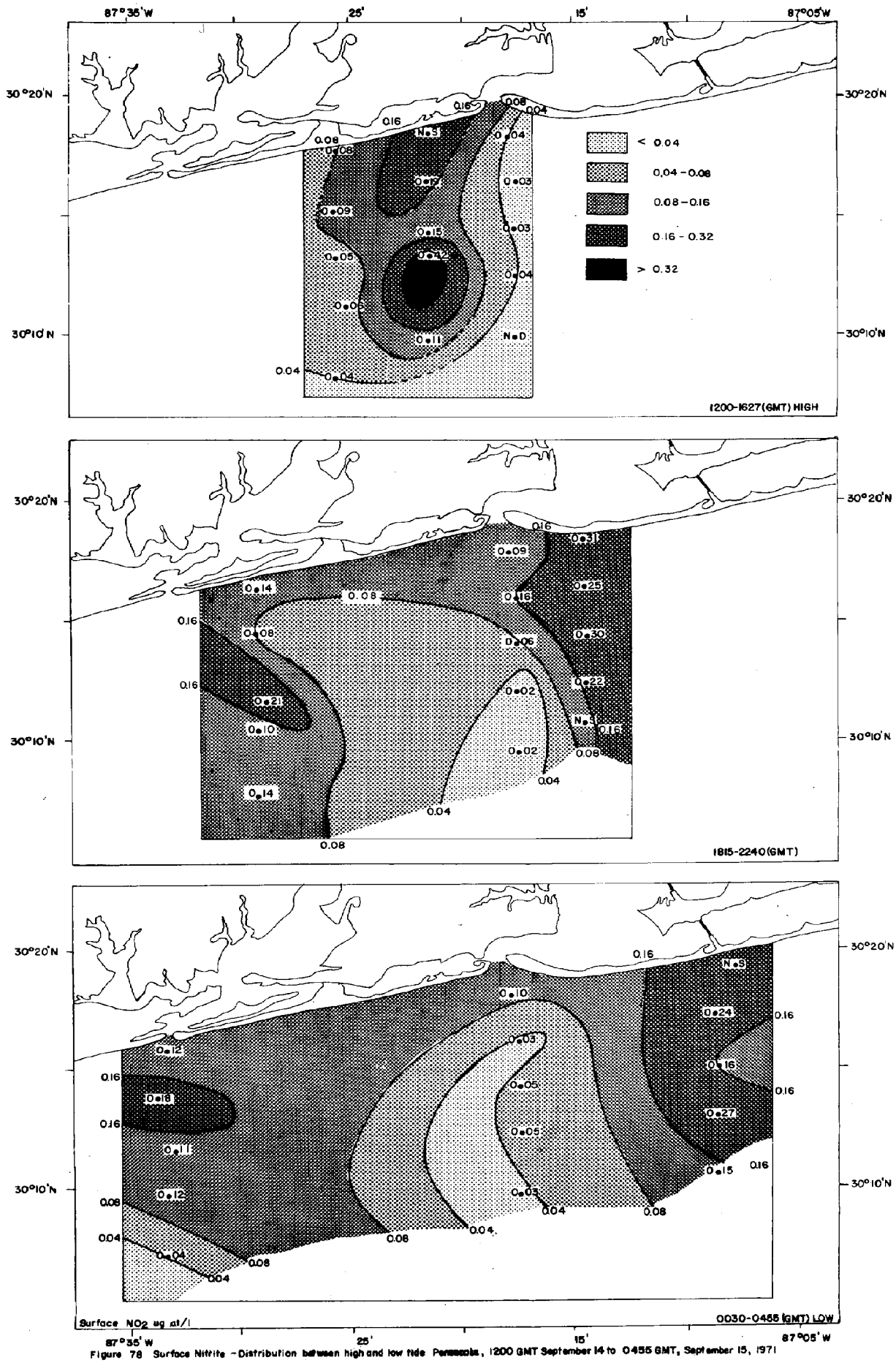


Figure 78 Surface Nitrite - Distribution between high and low tide Pensacola, 1200 GMT September 14 to 0455 GMT, September 15, 1971

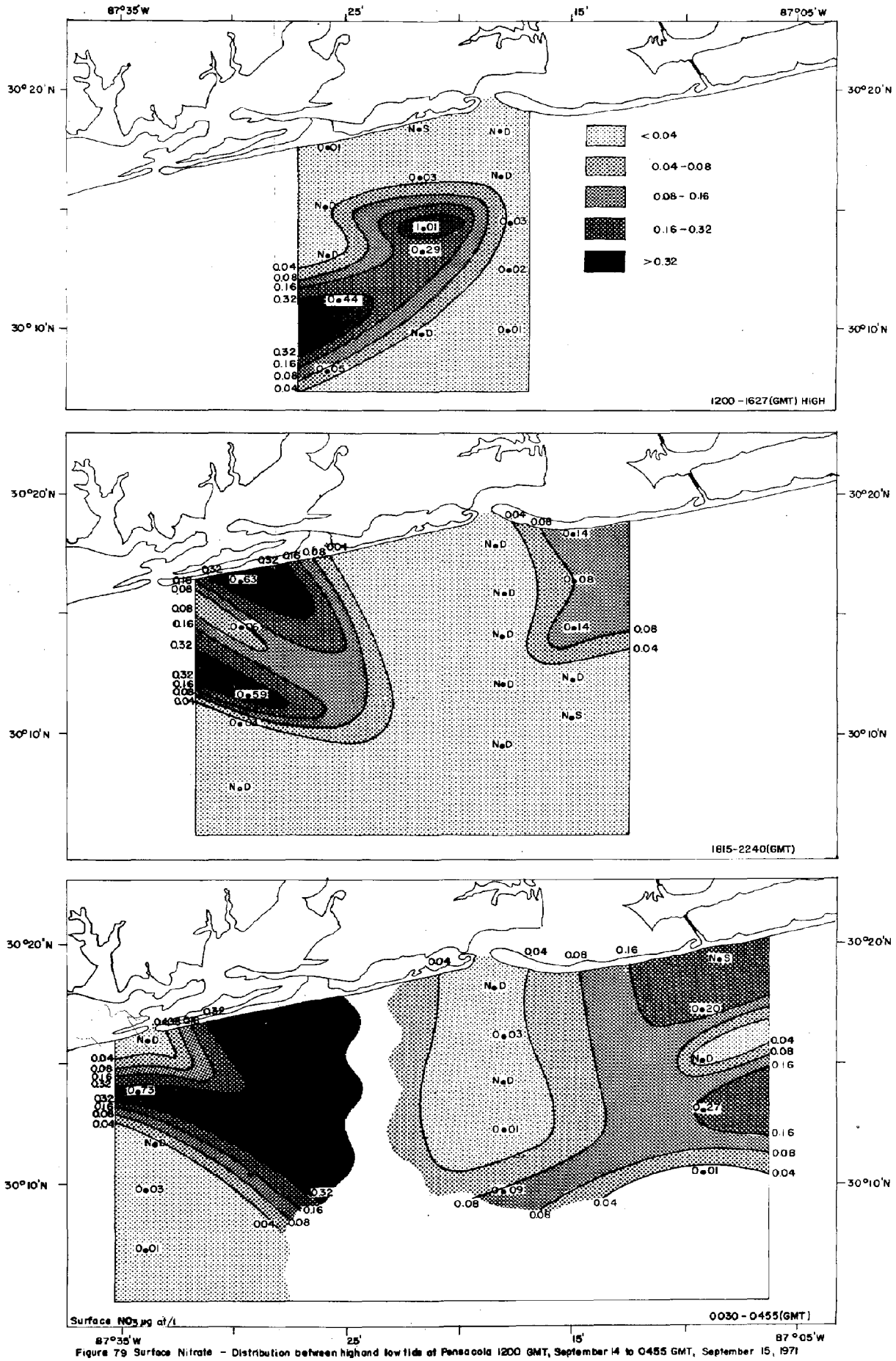


Figure 79 Surface Nitrate – Distribution between high and low tide at Pensacola 1200 GMT, September 14 to 0455 GMT, September 15, 1971

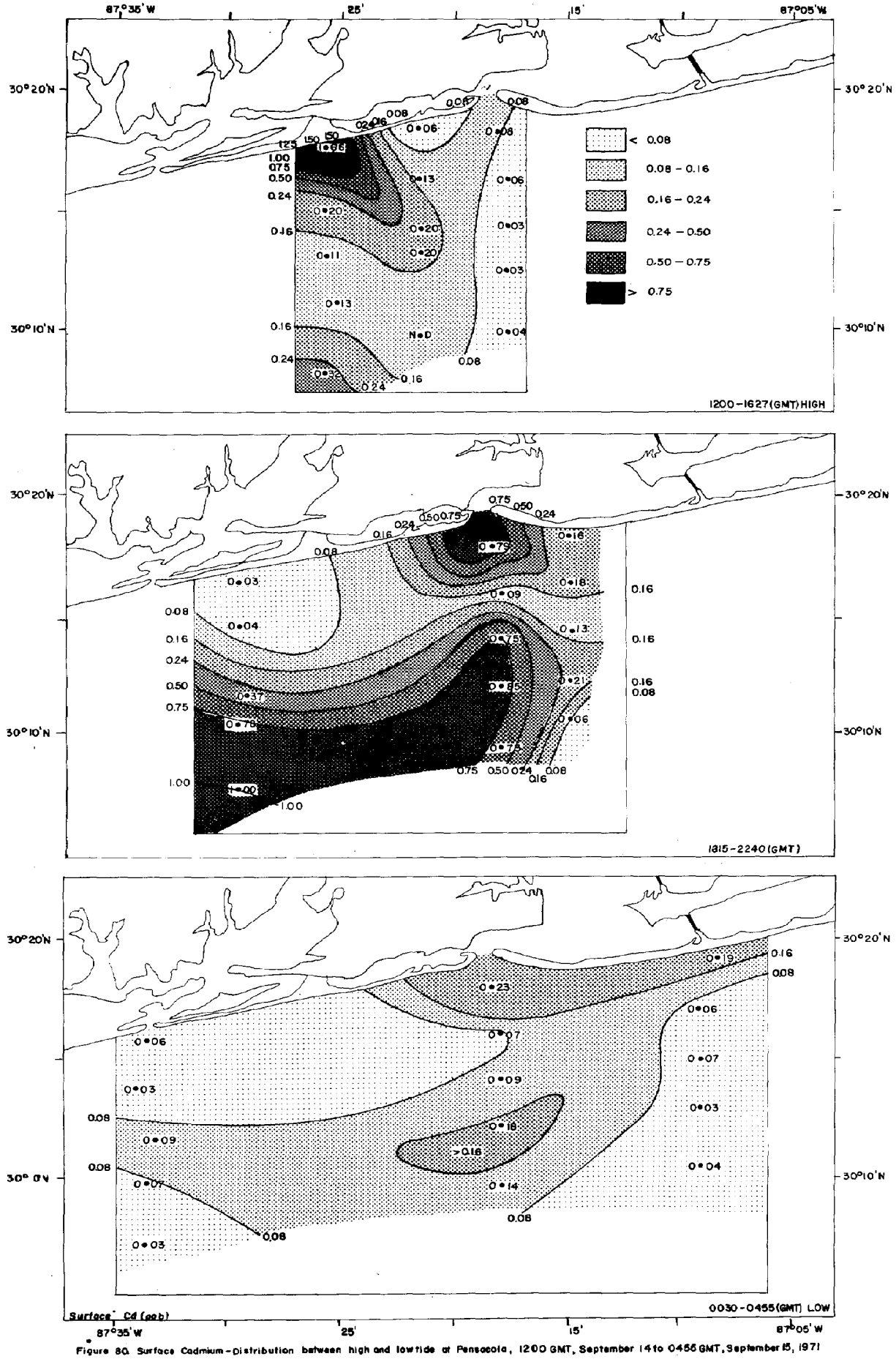


Figure 80. Surface Cadmium-Distribution between high and low tide at Pensacola, 1200 GMT, September 14 to 0456 GMT, September 15, 1971

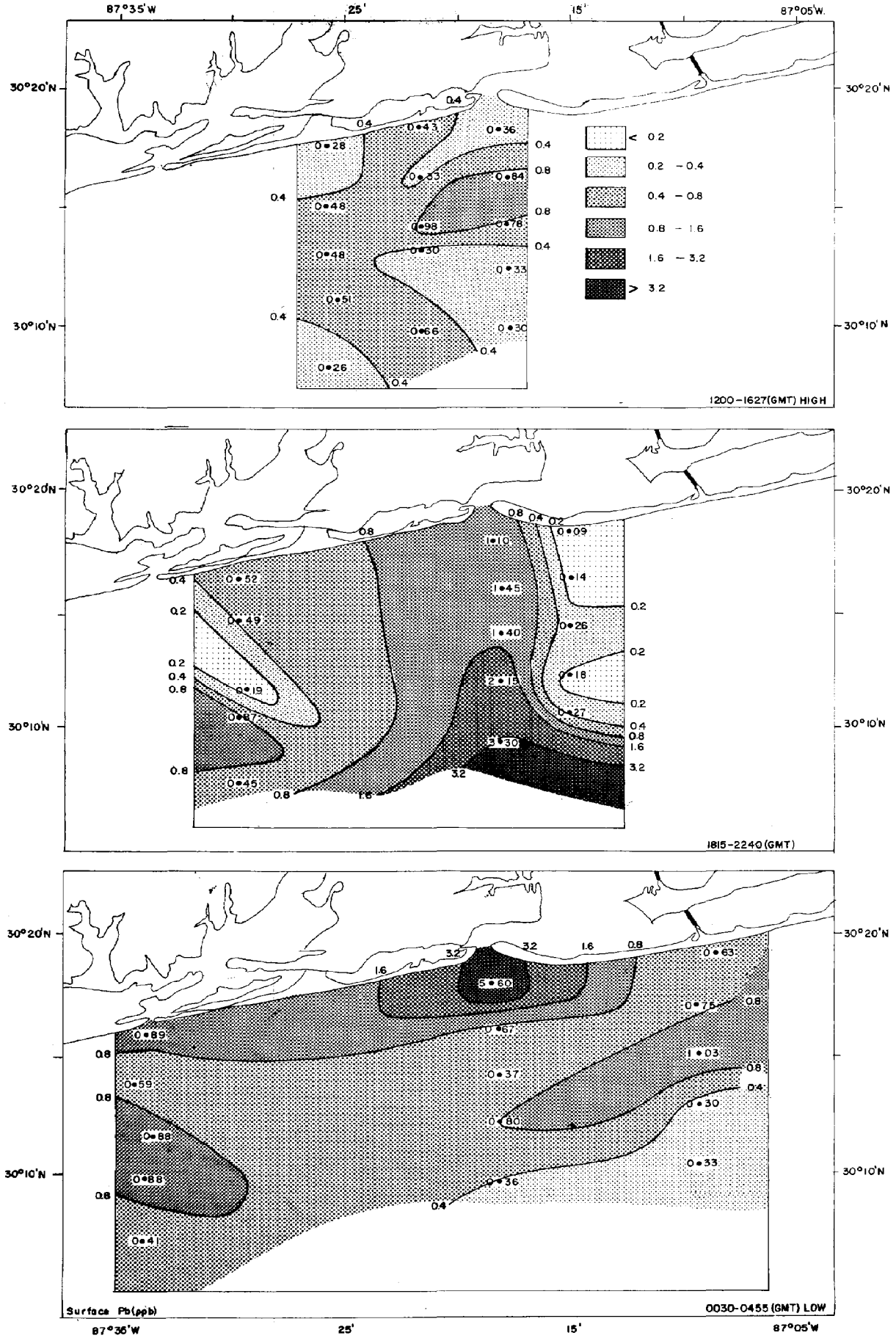


Figure 61 Surface Lead - Distribution between high and low tide at Pensacola, 1200 GMT, September 14 to 0455 GMT, September 15, 1971

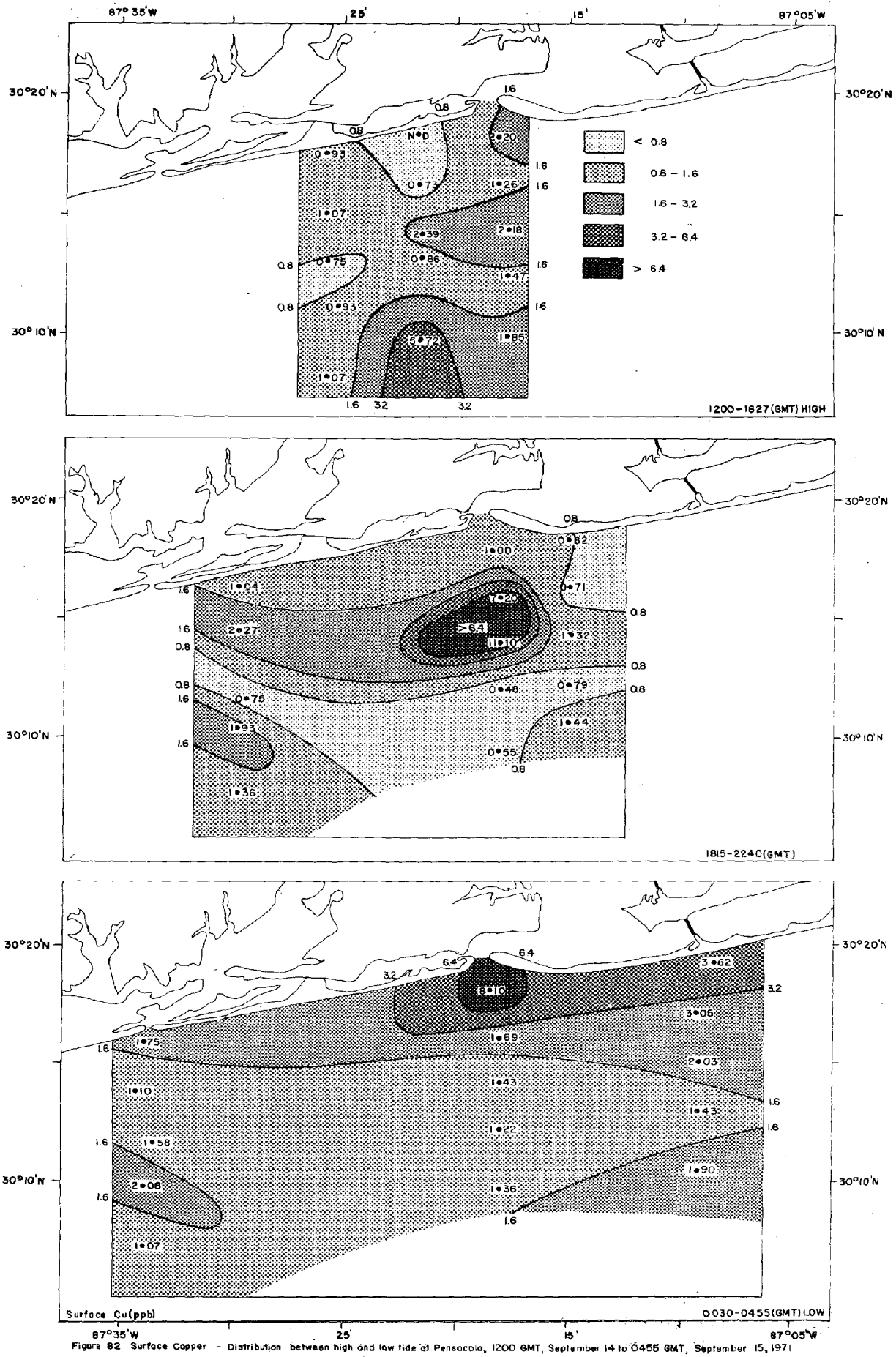


Figure 82 Surface Copper - Distribution between high and low tide at Pensacola, 1200 GMT, September 14 to 0455 GMT, September 15, 1971

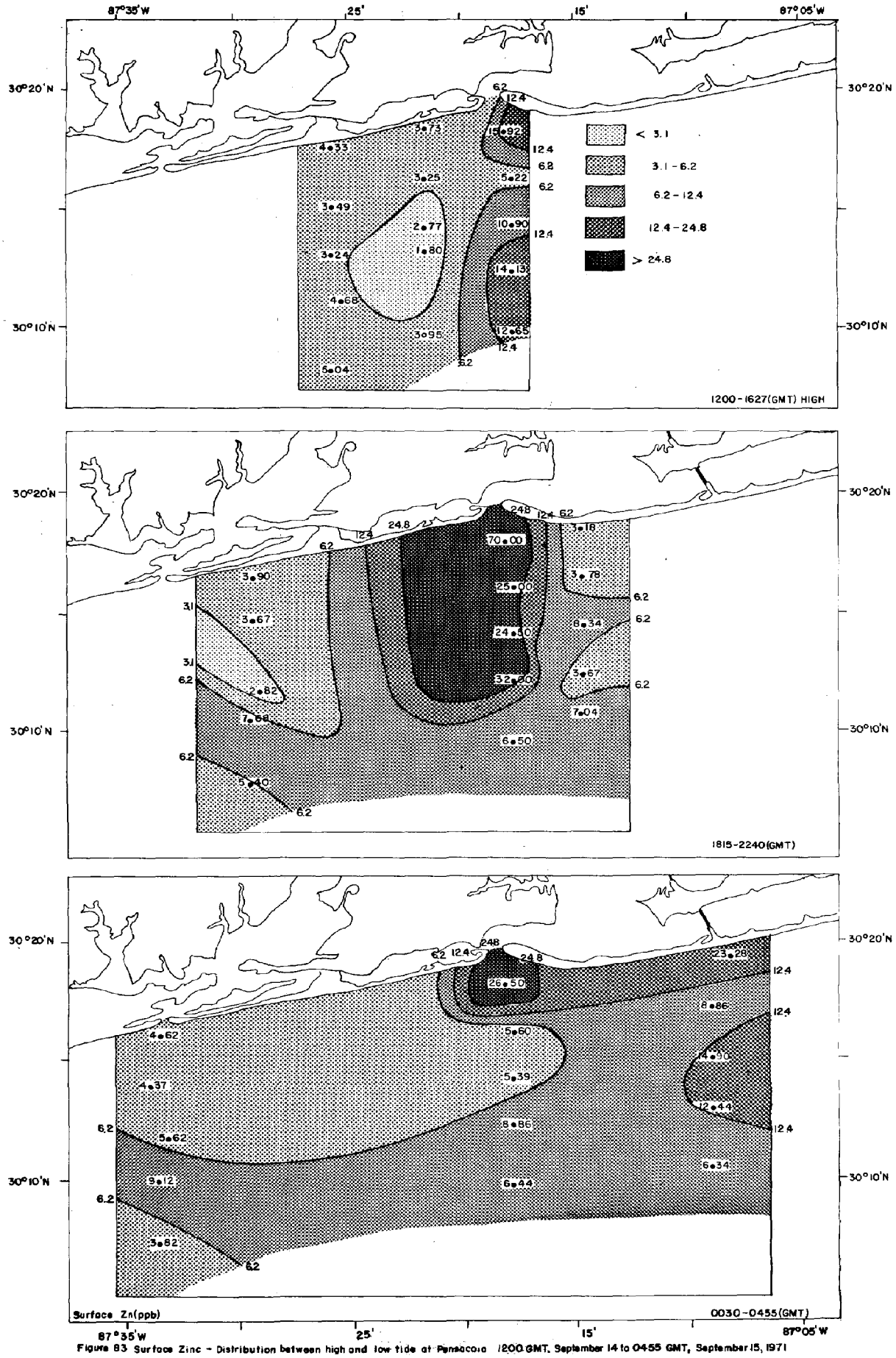


Figure 83 Surface Zinc - Distribution between high and low tide at Pensacola 1200 GMT, September 14 to 0455 GMT, September 15, 1971

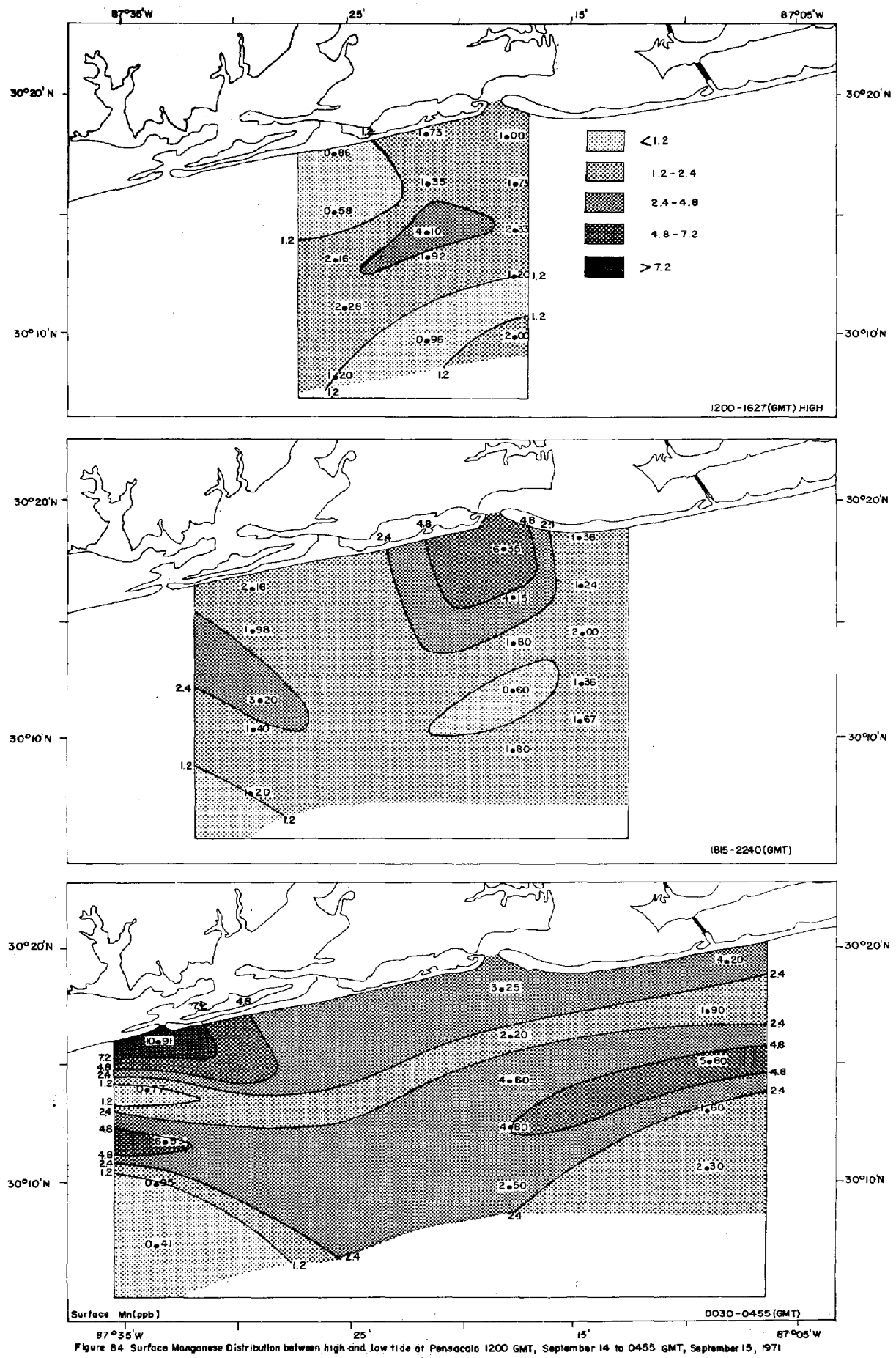


Figure 84 Surface Manganese Distribution between high and low tide at Pensacola 1200 GMT, September 14 to 0455 GMT, September 15, 1971

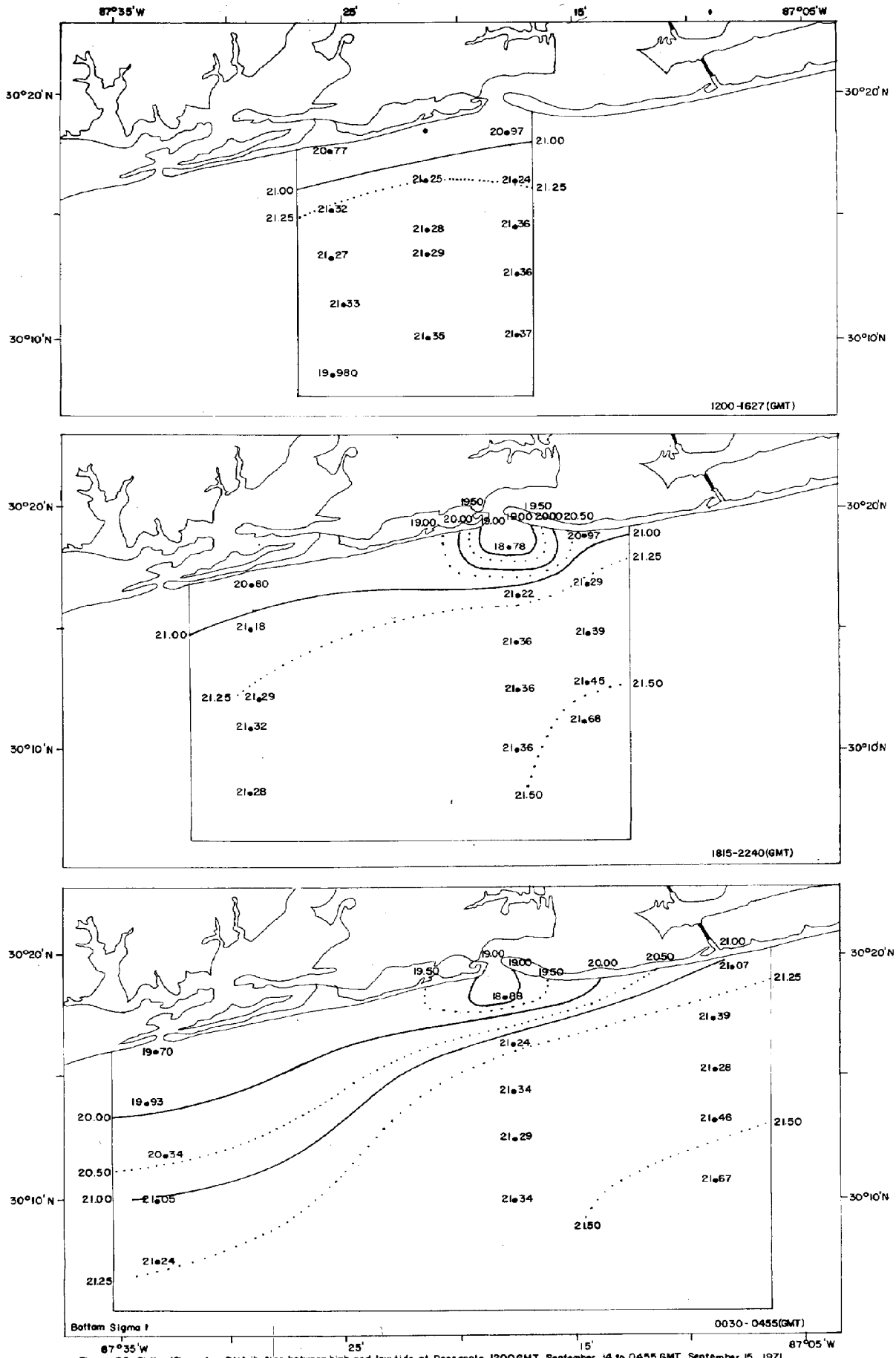


Figure 85 Bottom Sigma t Distribution between high and low tide at Pensacola 1200GMT, September 14 to 0455 GMT, September 15, 1971

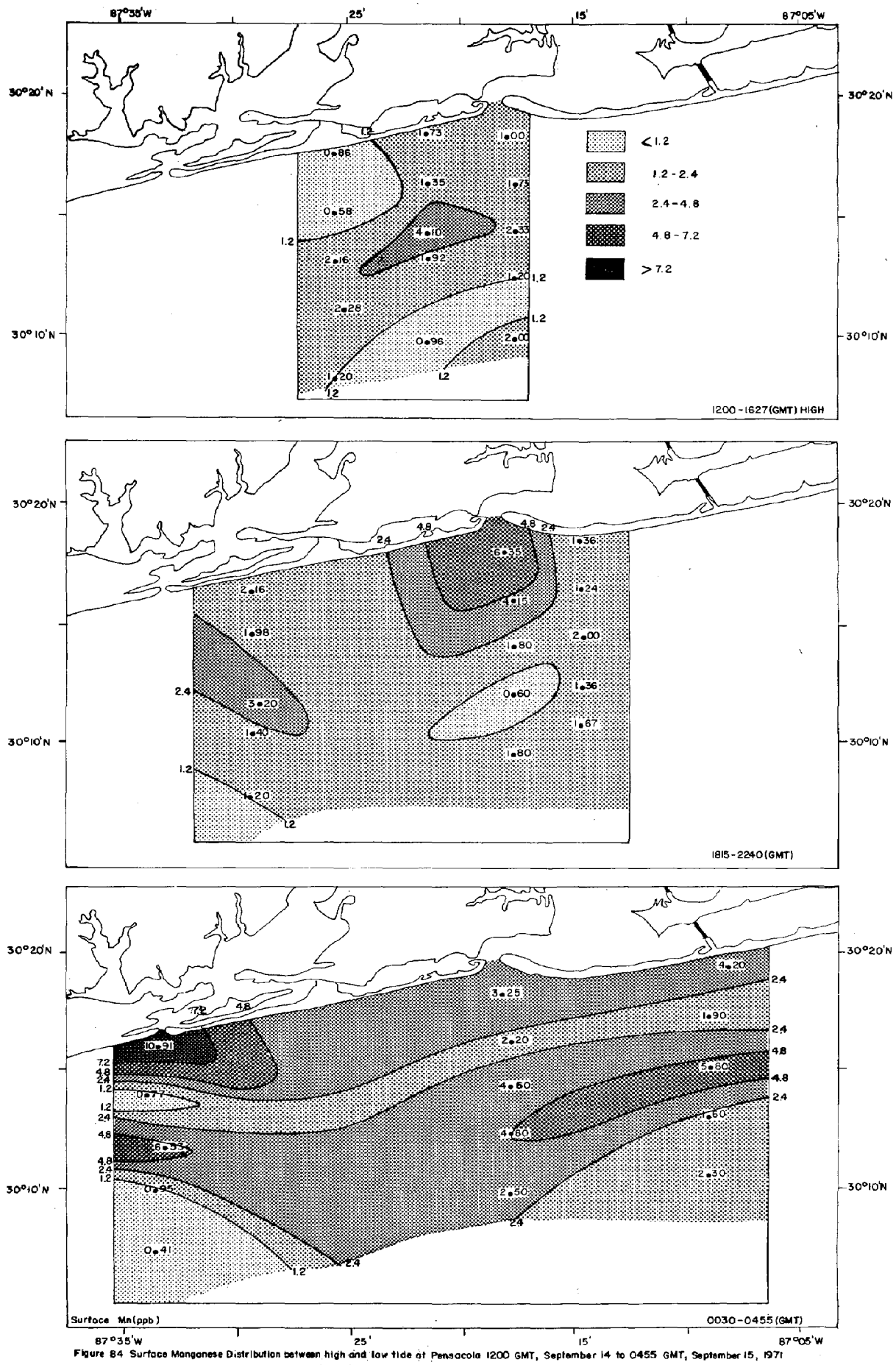


Figure 84 Surface Manganese Distribution between high and low tide at Pensacola 1200 GMT, September 14 to 0455 GMT, September 15, 1971

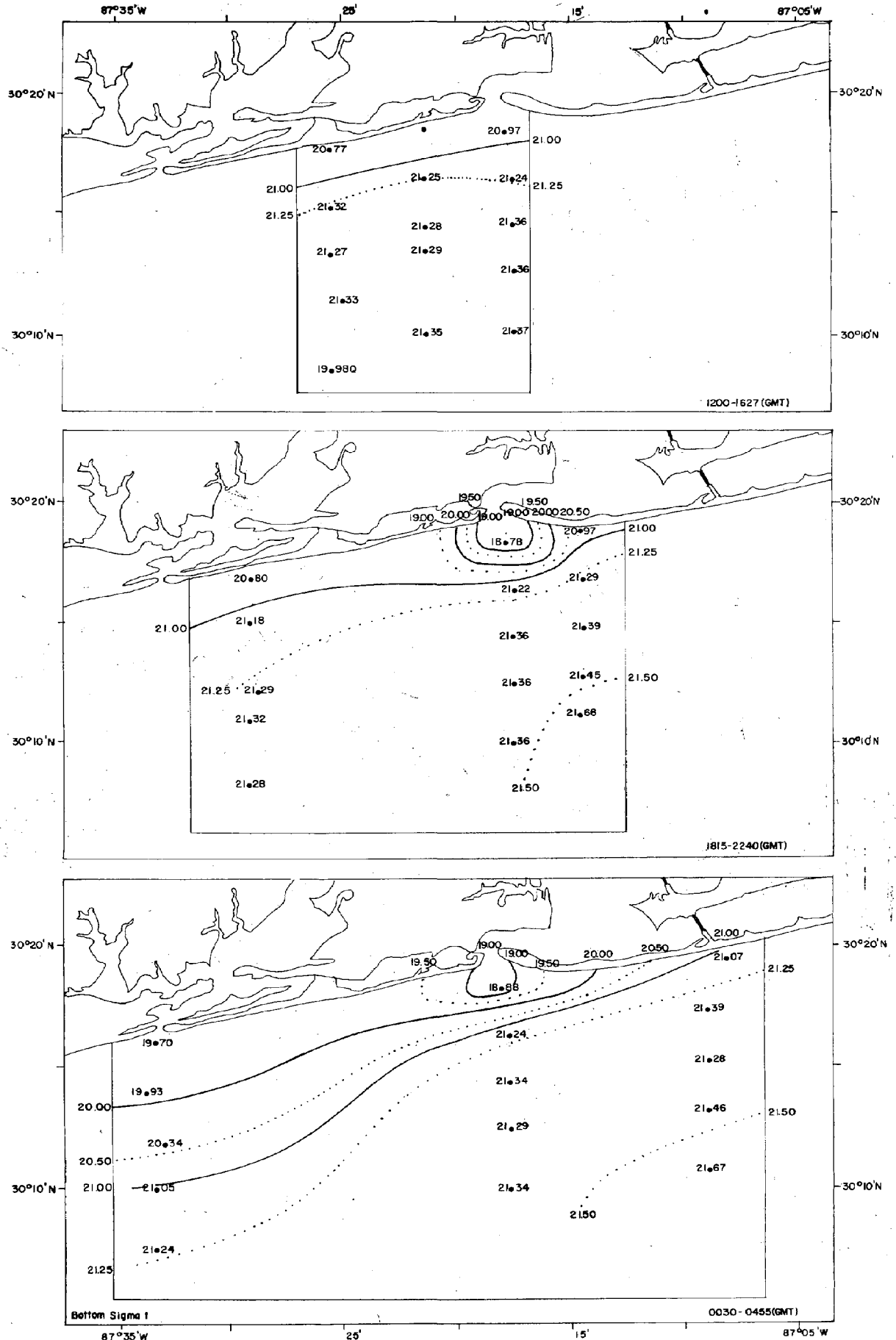


Figure 85 Bottom Sigma t Distribution between high and low tide at Pensacola 1200GMT, September 14 to 0455 GMT, September 15, 1971

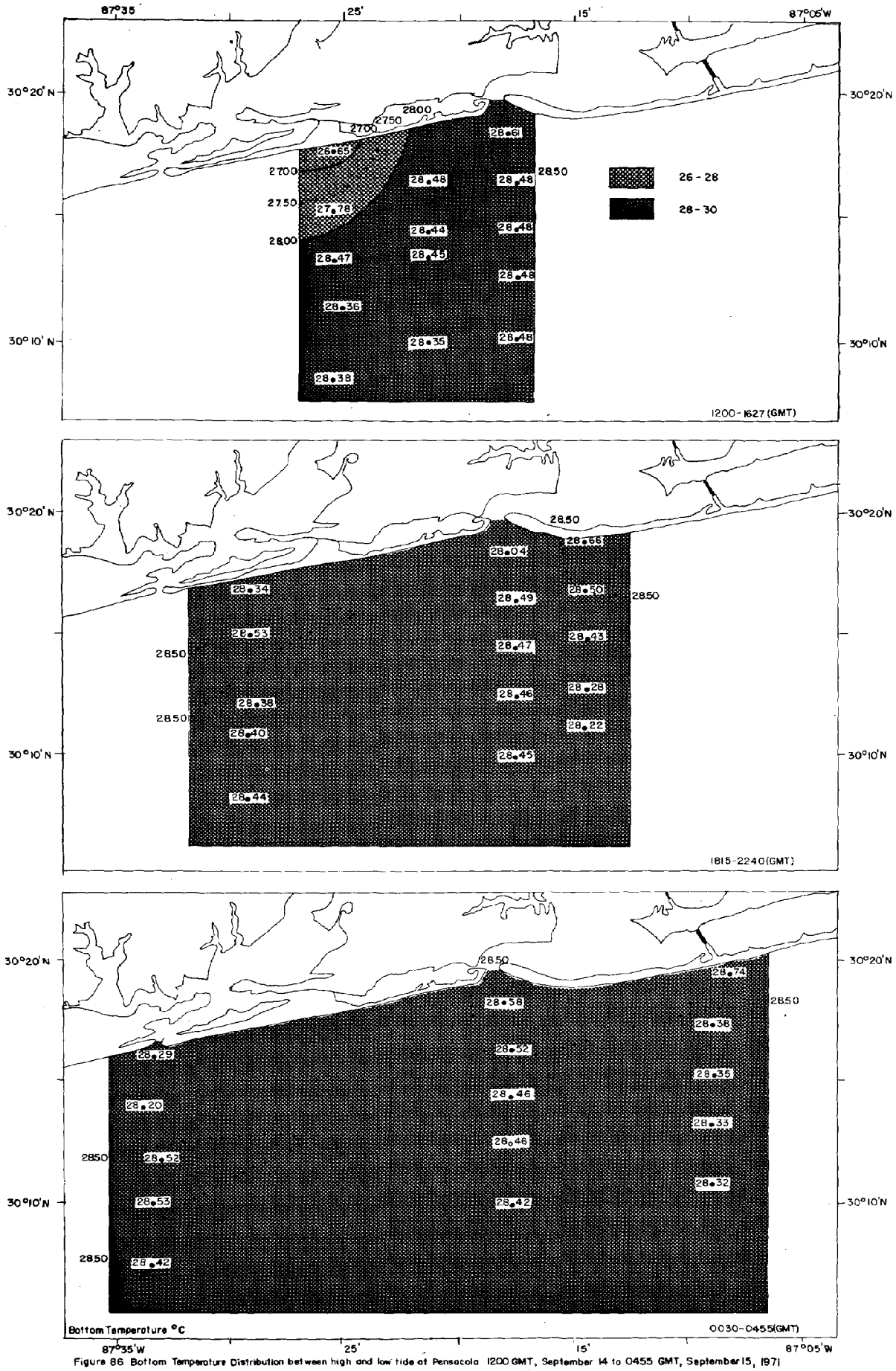


Figure 86 Bottom Temperature Distribution between high and low tide at Pensacola 1200 GMT, September 14 to 0455 GMT, September 15, 1971

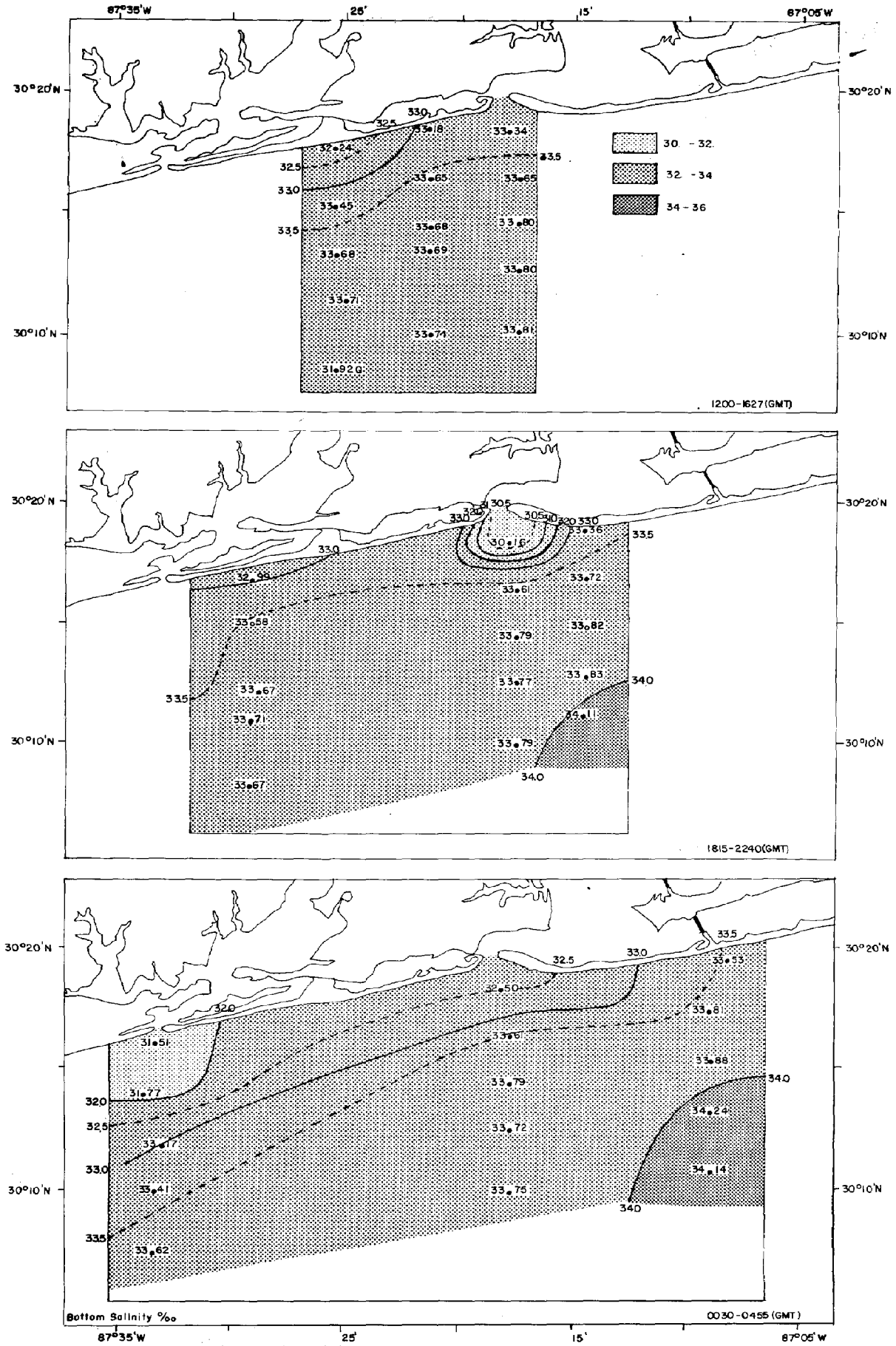


Figure 87 Bottom Salinity Distribution between high and low tide at Pensacola 1200 GMT, September 14 to 0455 GMT, September 15, 1971

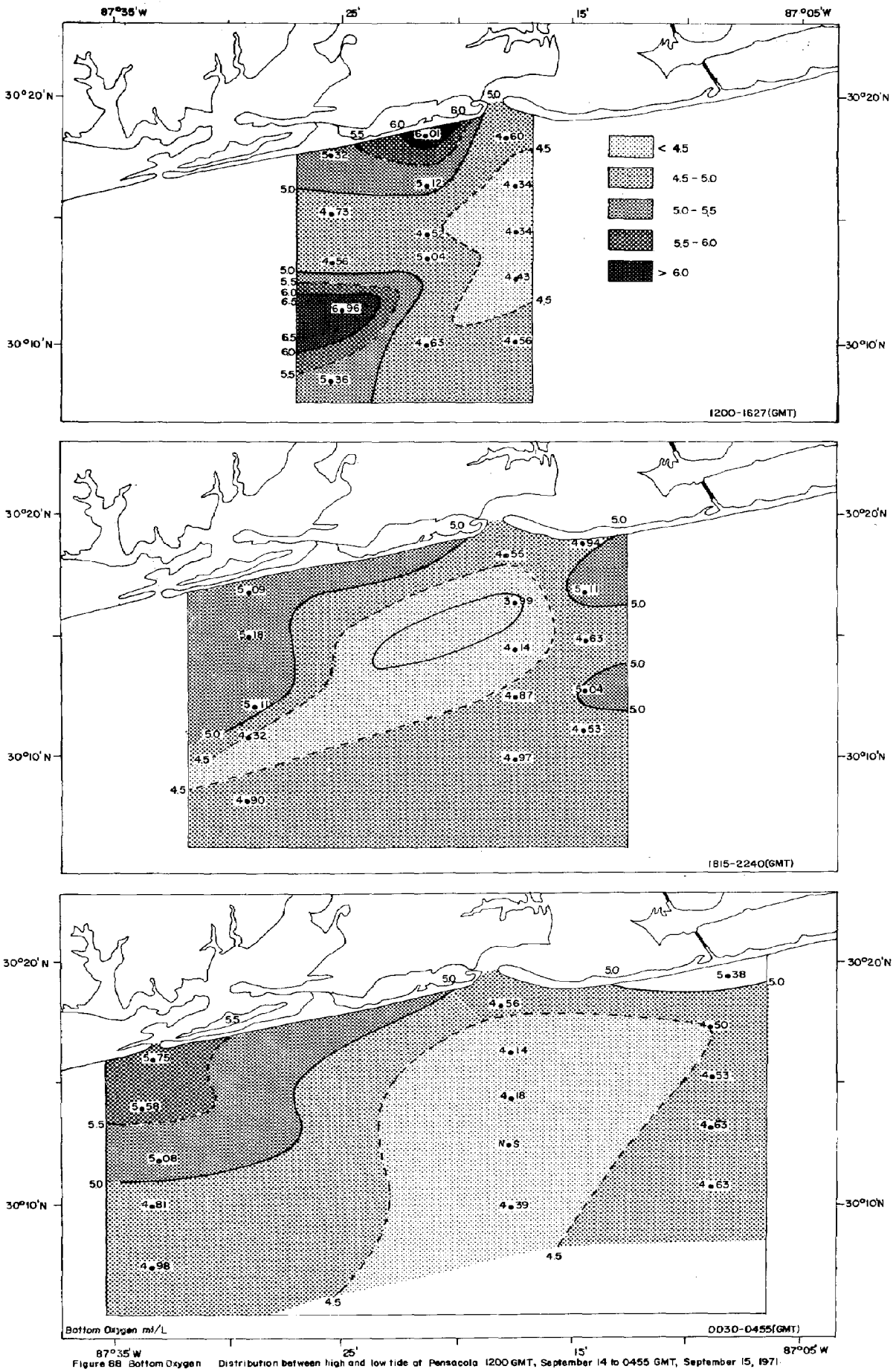


Figure 88 Bottom Oxygen Distribution between high and low tide at Pensacola 1200 GMT, September 14 to 0455 GMT, September 15, 1971

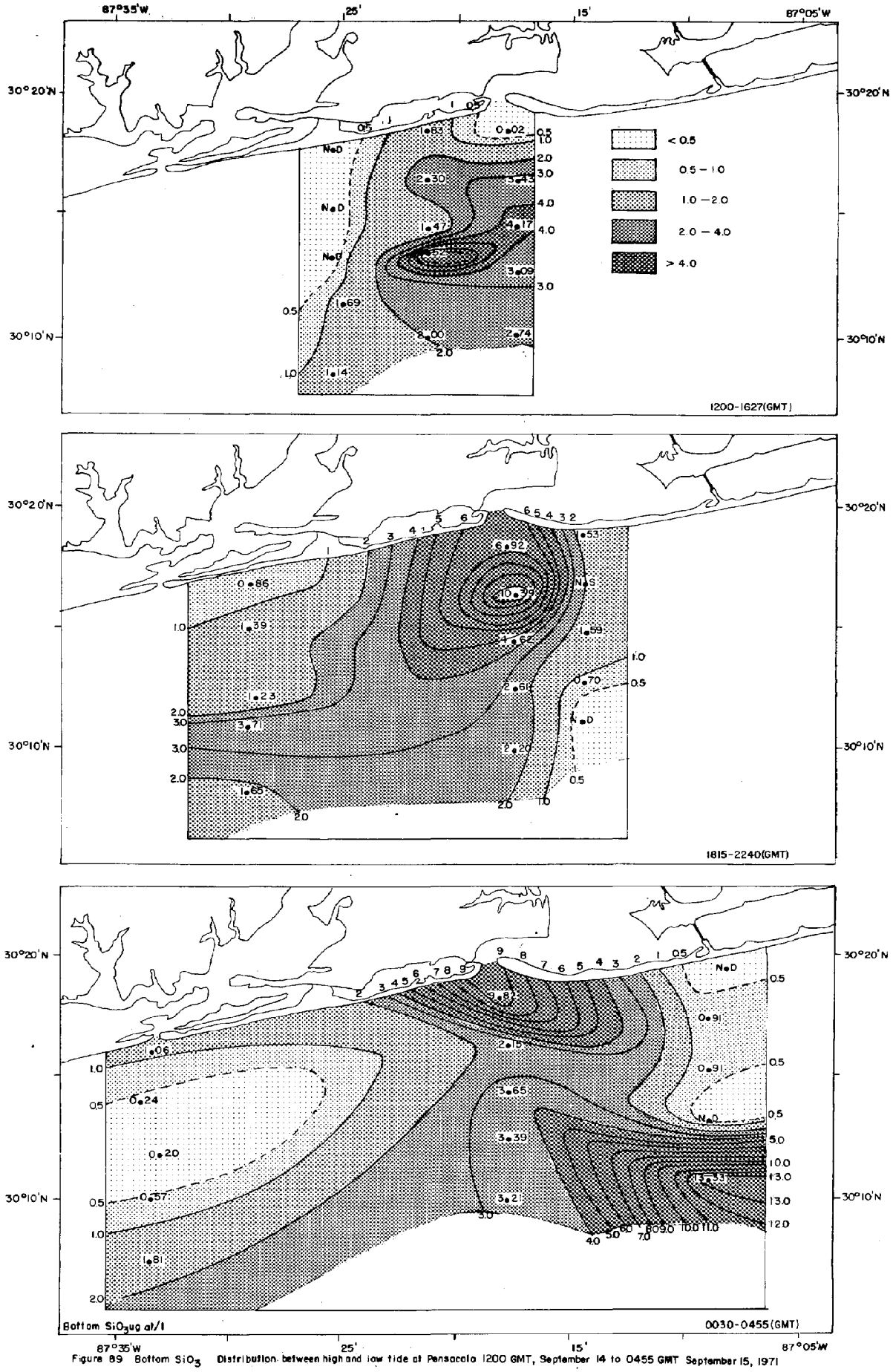


Figure 89 Bottom SiO_3 Distribution between high and low tide at Pensacola 1200 GMT, September 14 to 0455 GMT September 15, 1971

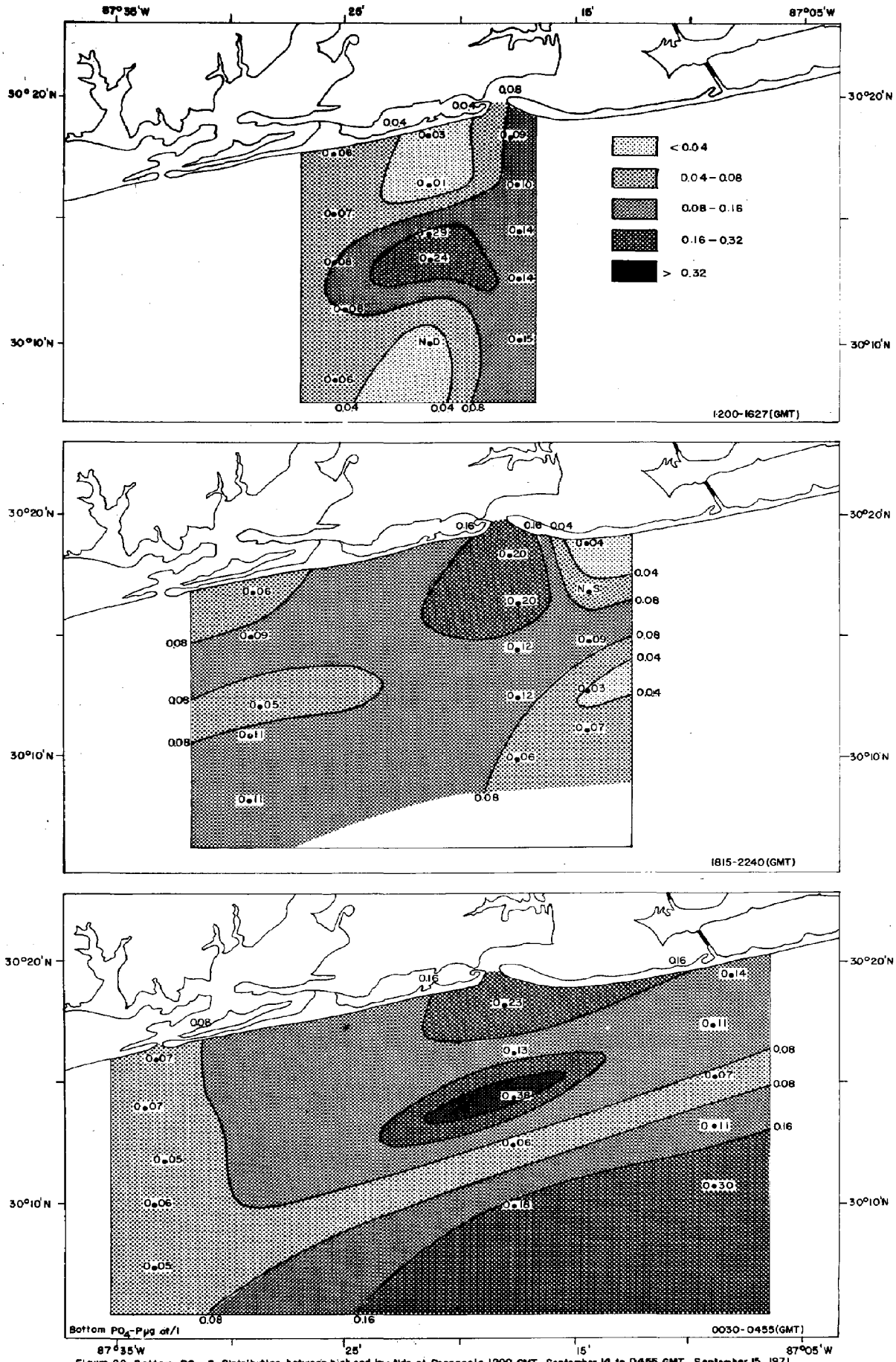


Figure 90 Bottom PO_4-P Distribution between high and low tide of Pensacola 1200 GMT, September 14 to 0455 GMT, September 15, 1971

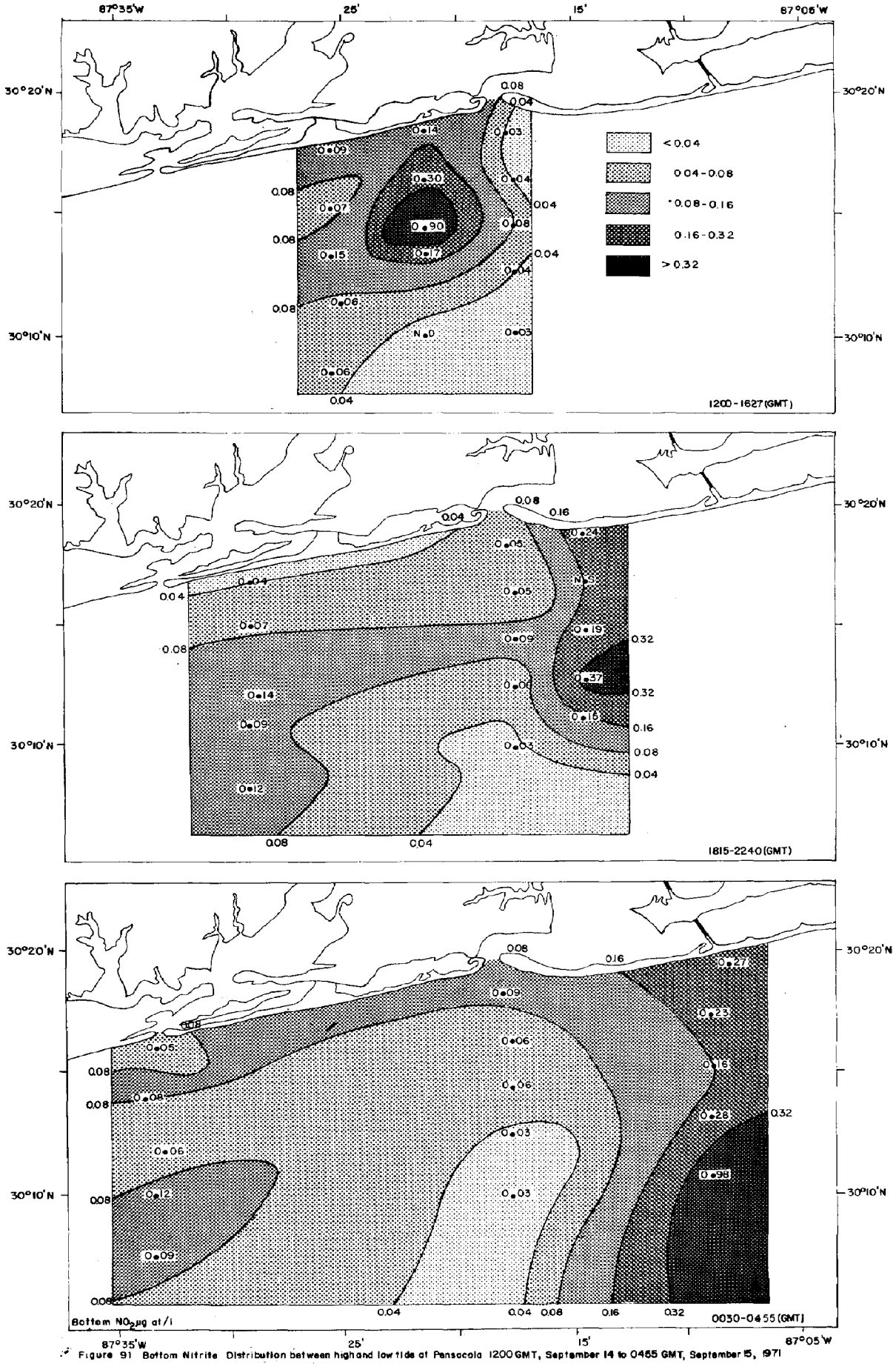


Figure 91 Bottom Nitrite Distribution between high and low tide at Pensacola 1200 GMT, September 14 to 0455 GMT, September 15, 1971

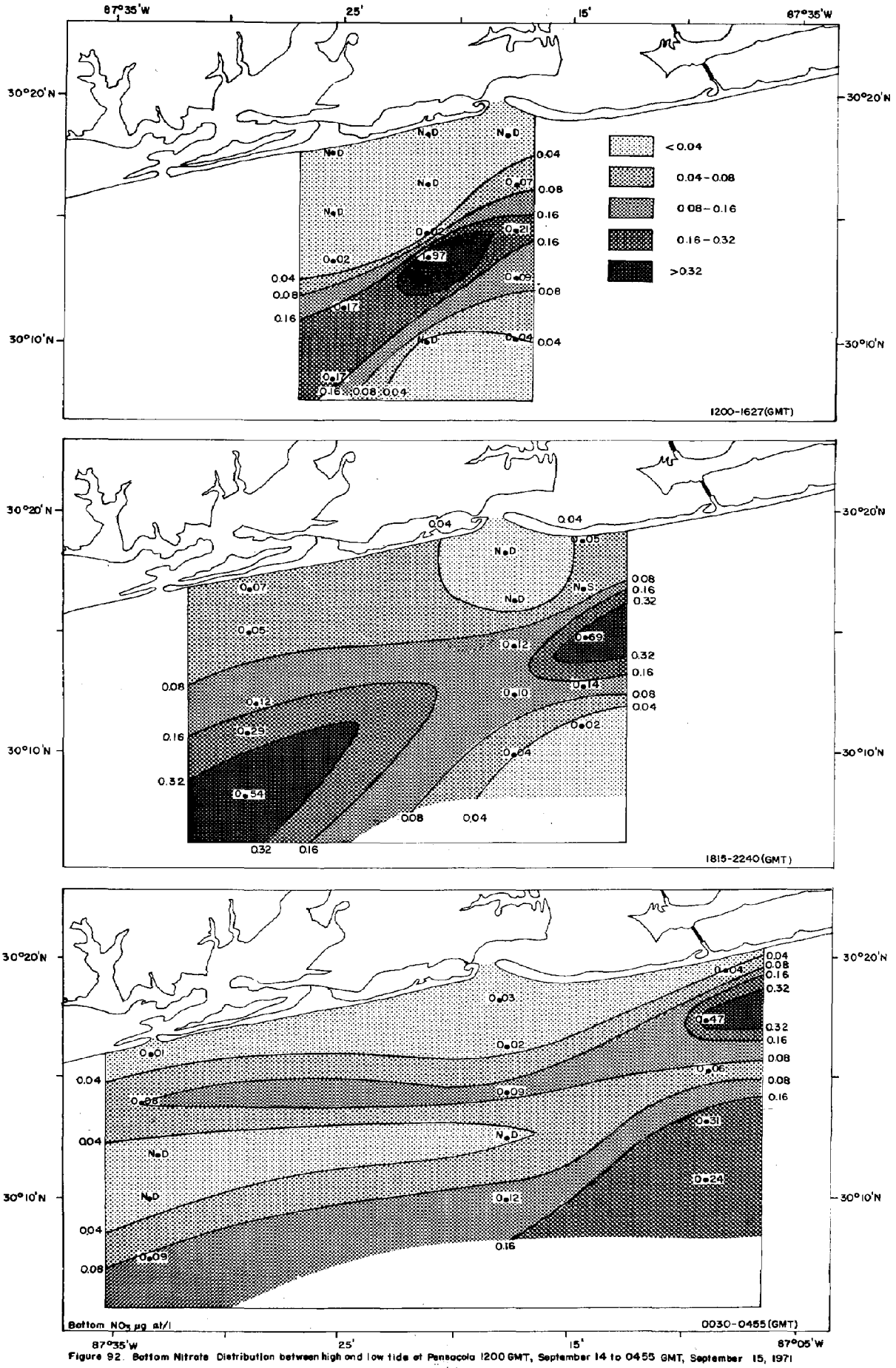


Figure 92. Bottom Nitrate Distribution between high and low tide at Pensacola 1200 GMT, September 14 to 0455 GMT, September 15, 1971

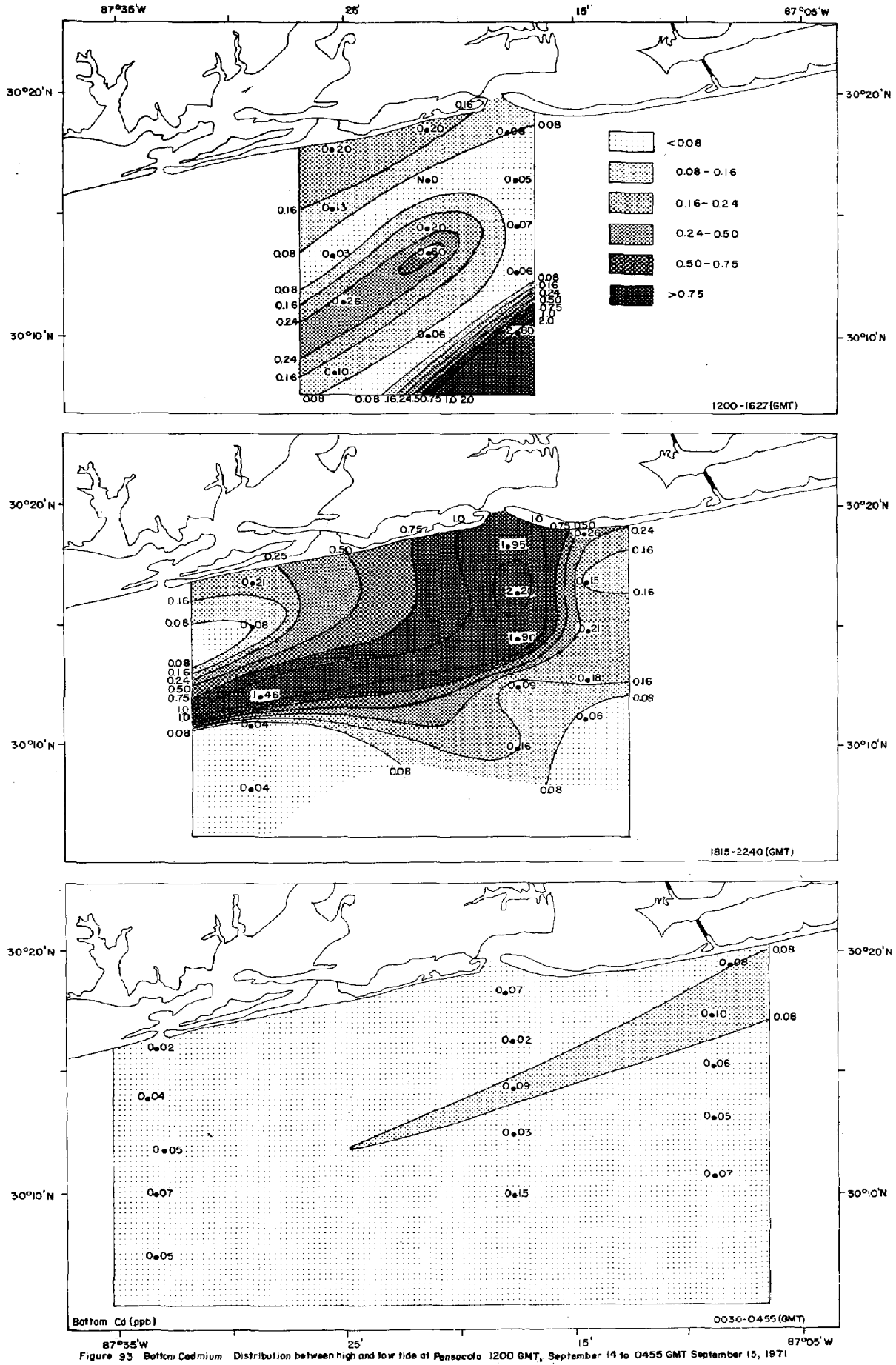


Figure 93 Bottom Cadmium Distribution between high and low tide at Pensacola 1200 GMT, September 14 to 0455 GMT September 15, 1971

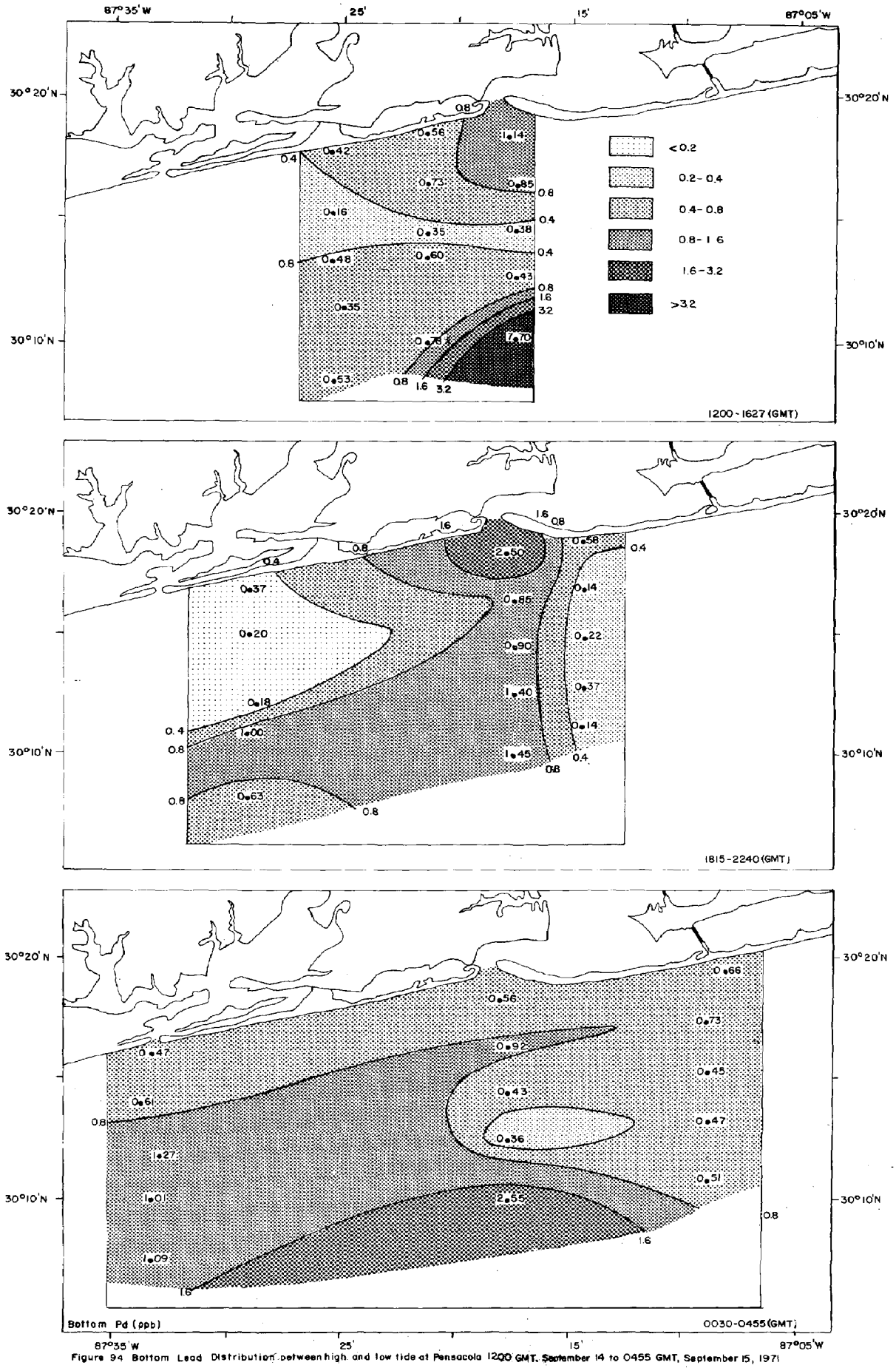


Figure 94 Bottom Lead Distribution between high and low tide at Pensacola 1200 GMT, September 14 to 0455 GMT, September 15, 1971

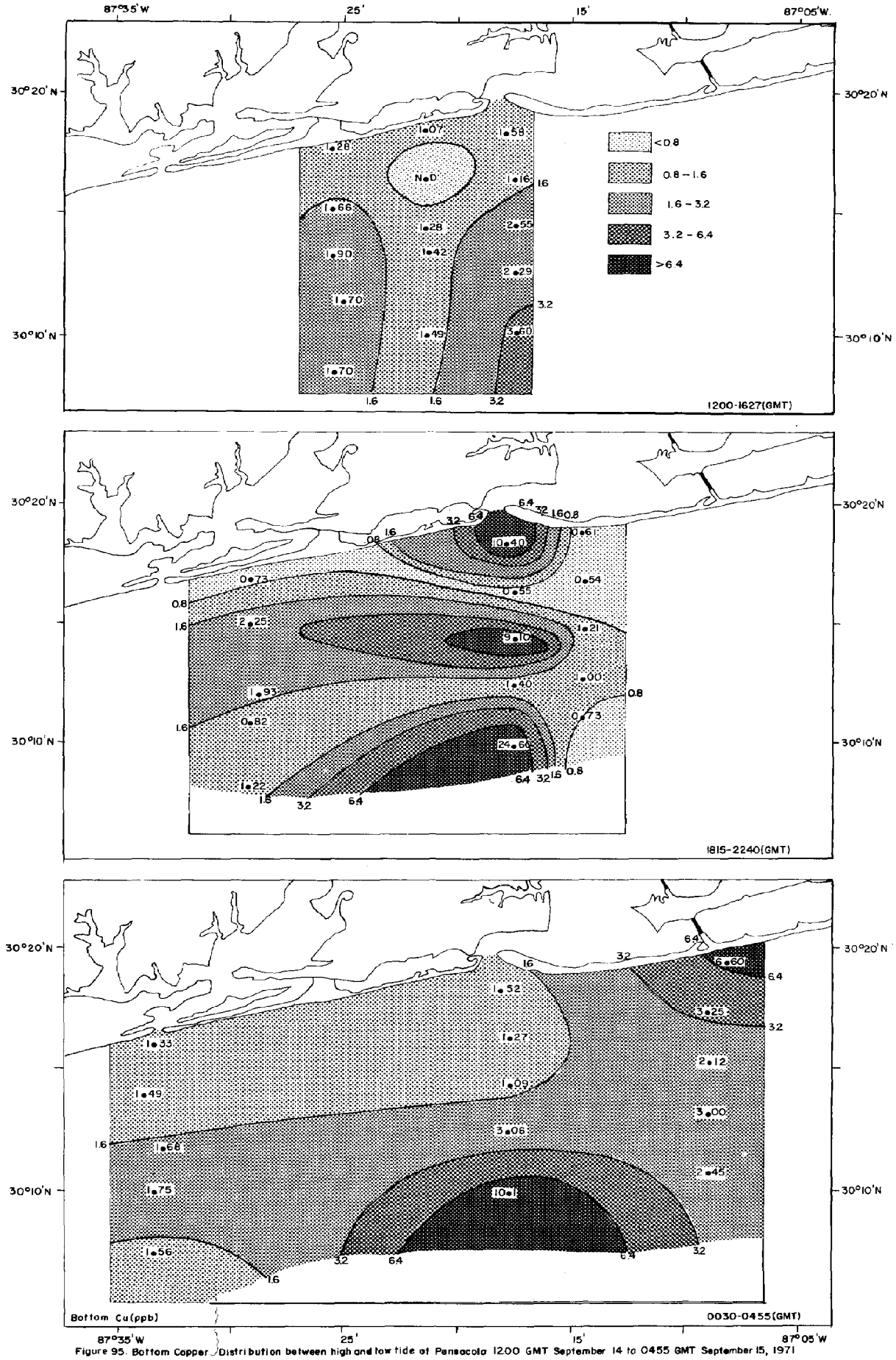


Figure 95. Bottom Copper Distribution between high and low tide of Pensacola 1200 GMT September 14 to 0455 GMT September 15, 1971

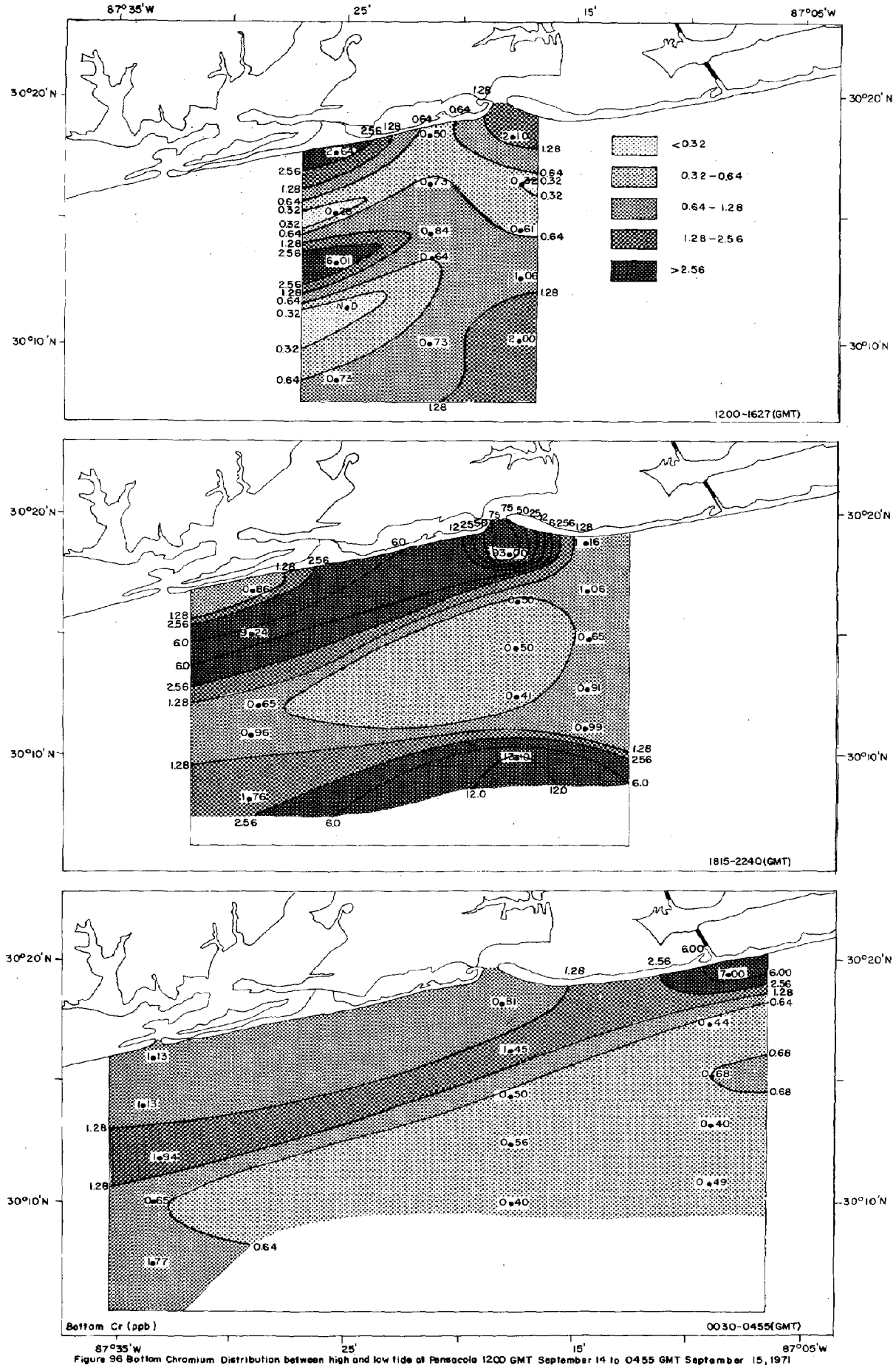


Figure 96 Bottom Chromium Distribution between high and low tide at Pensacola 1200 GMT September 14 to 0455 GMT September 15, 1971

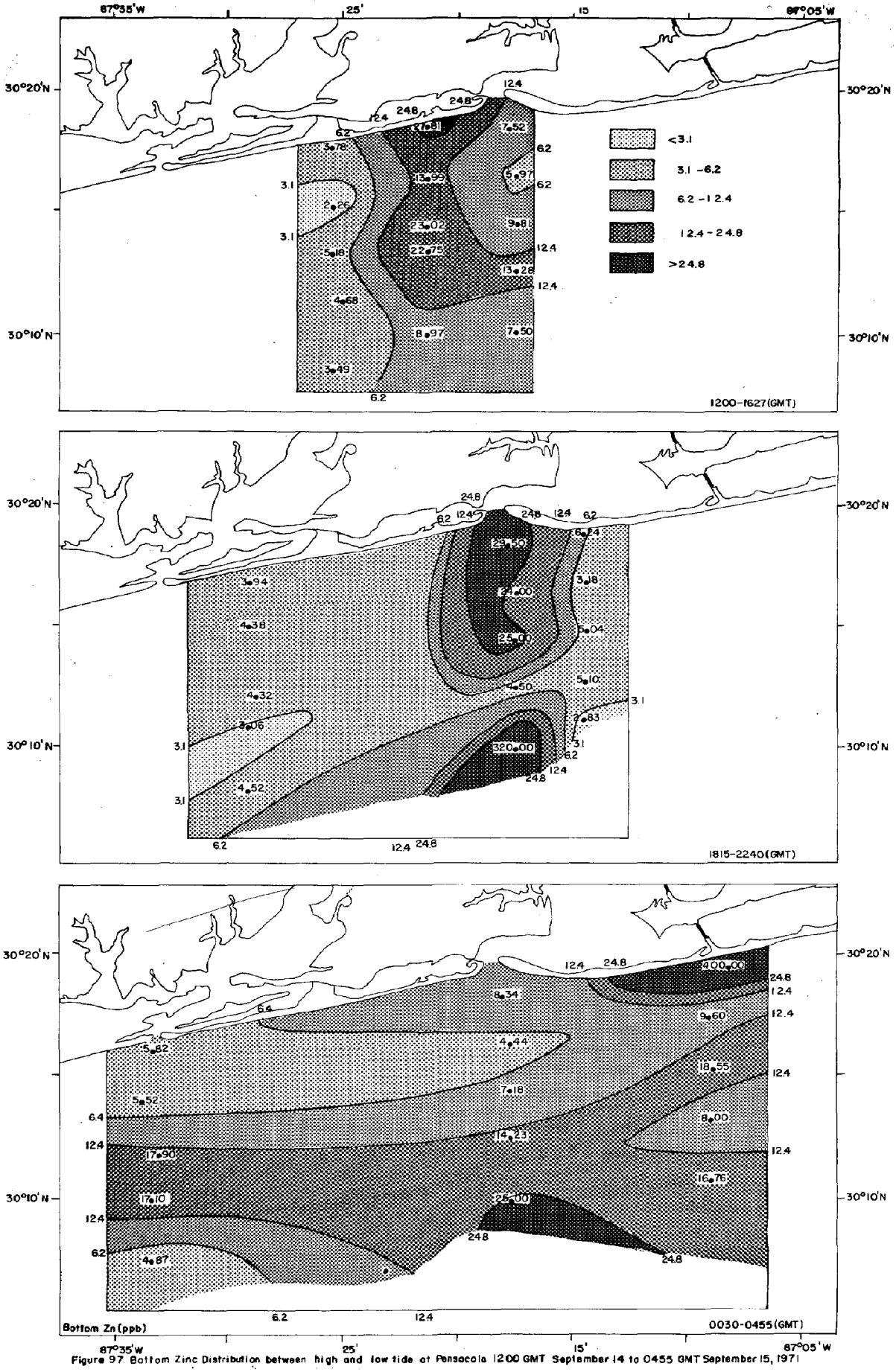


Figure 97 Bottom Zinc Distribution between high and low tide at Pensacola 1200 GMT September 14 to 0455 GMT September 15, 1971

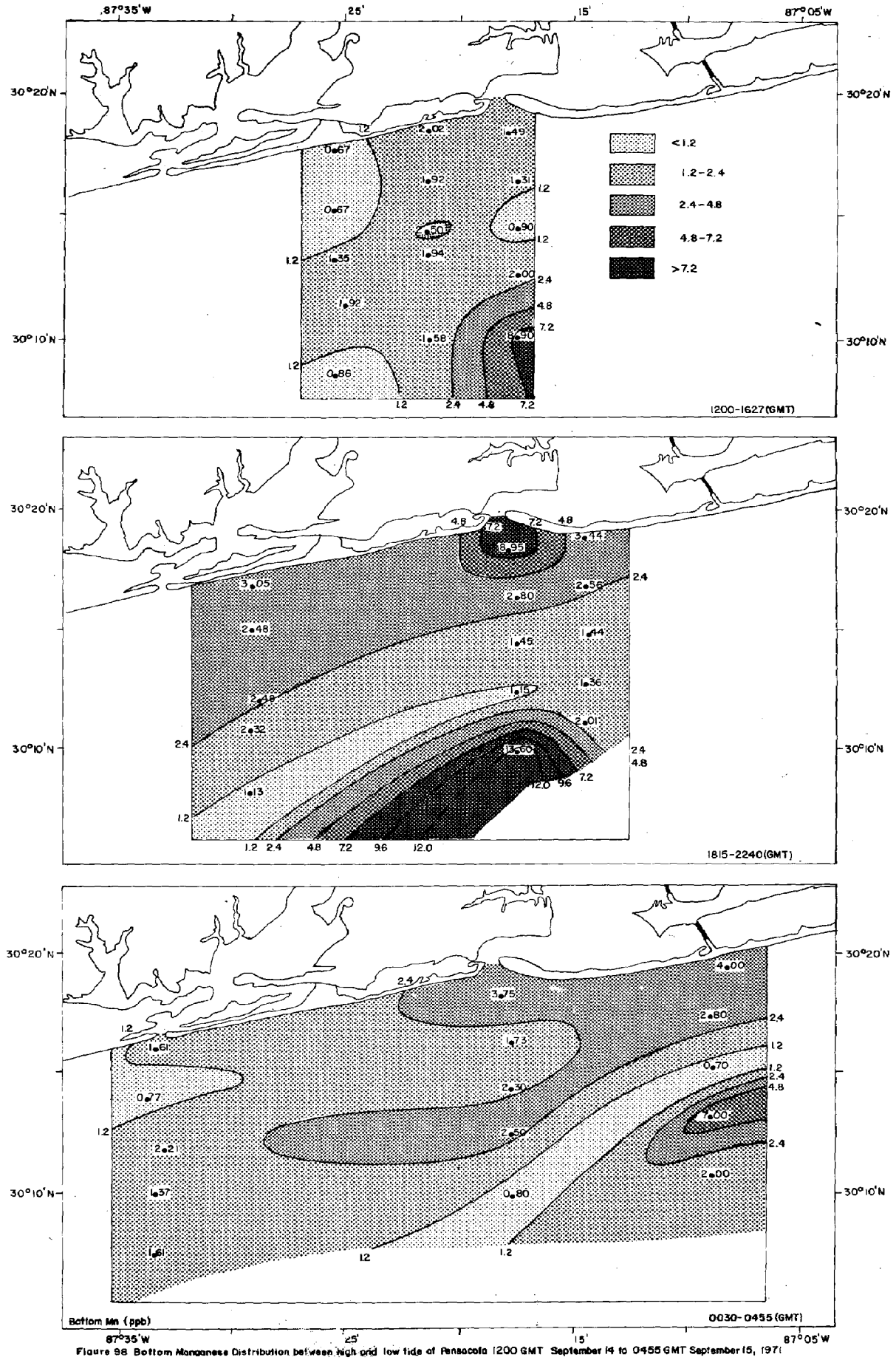


Figure 98 Bottom Manganese Distribution between high and low tide of Pensacola 1200 GMT September 14 to 0455 GMT September 15, 1971

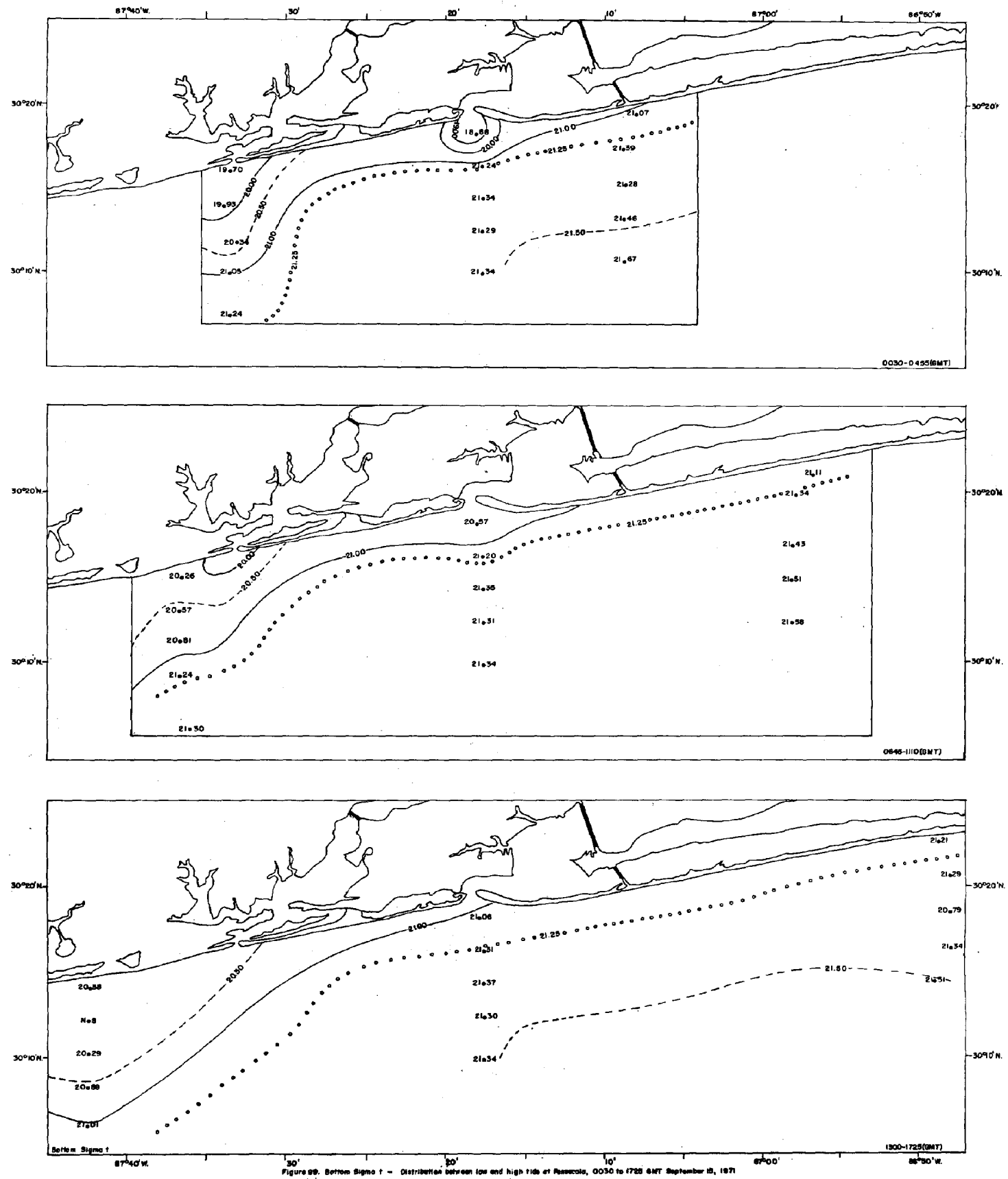


Figure 99. Bottom Sigma t – Distribution between low and high tide at Pascagoula, 0030 to 1725 GMT September 18, 1971

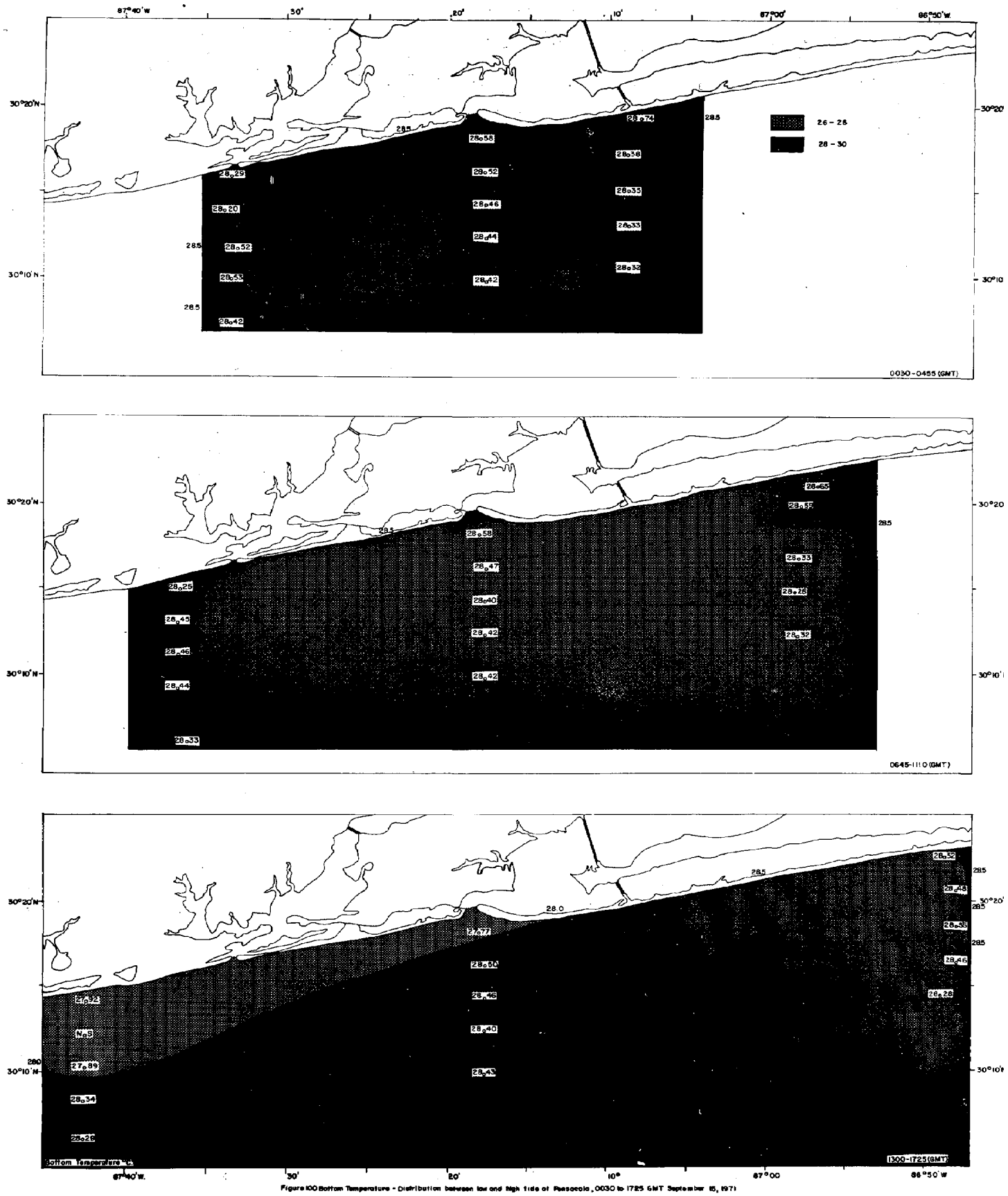
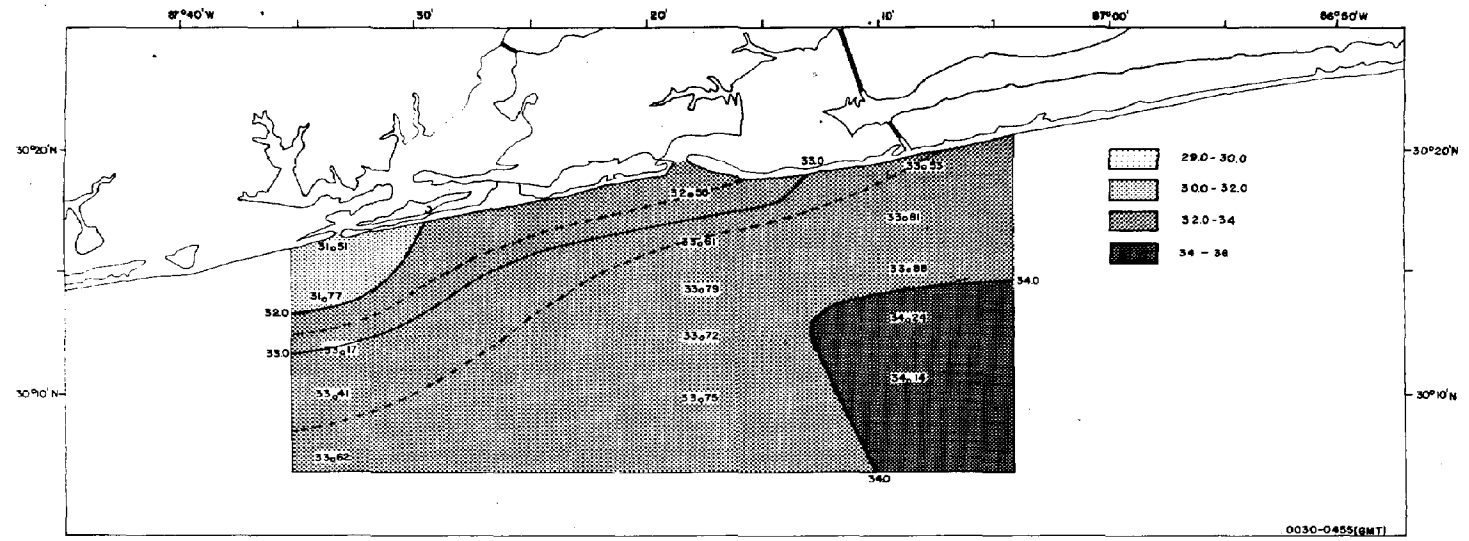
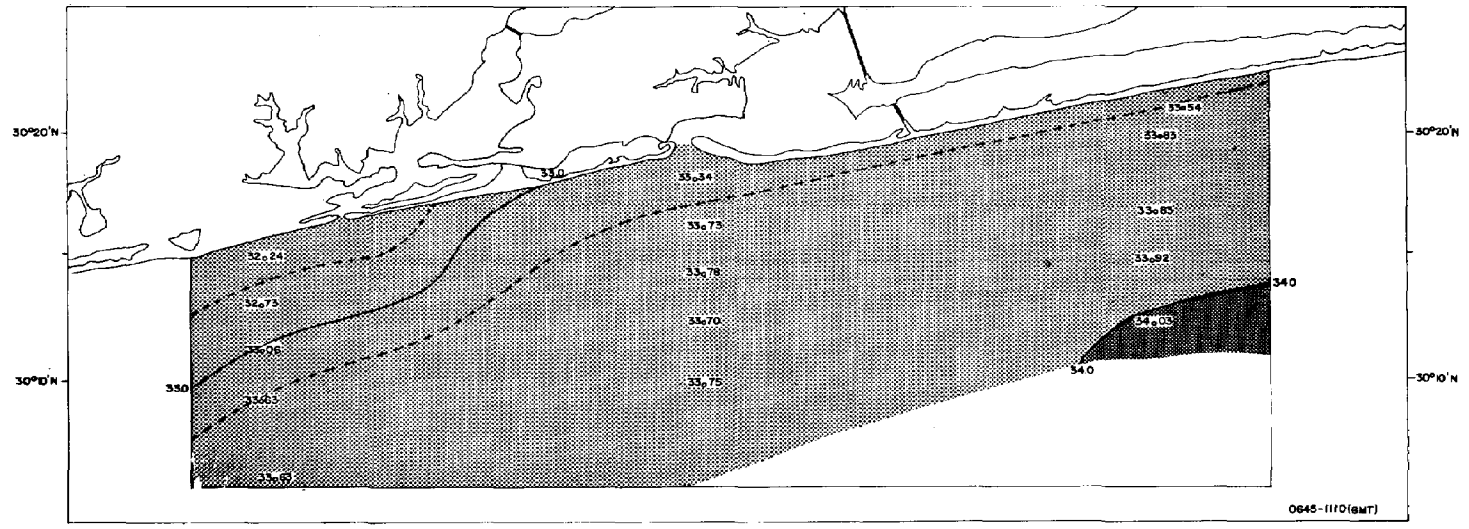


Figure 100 Bottom Temperature - Distribution between low and high tide at Pascagoula, 0030 to 1725 GMT September 15, 1971





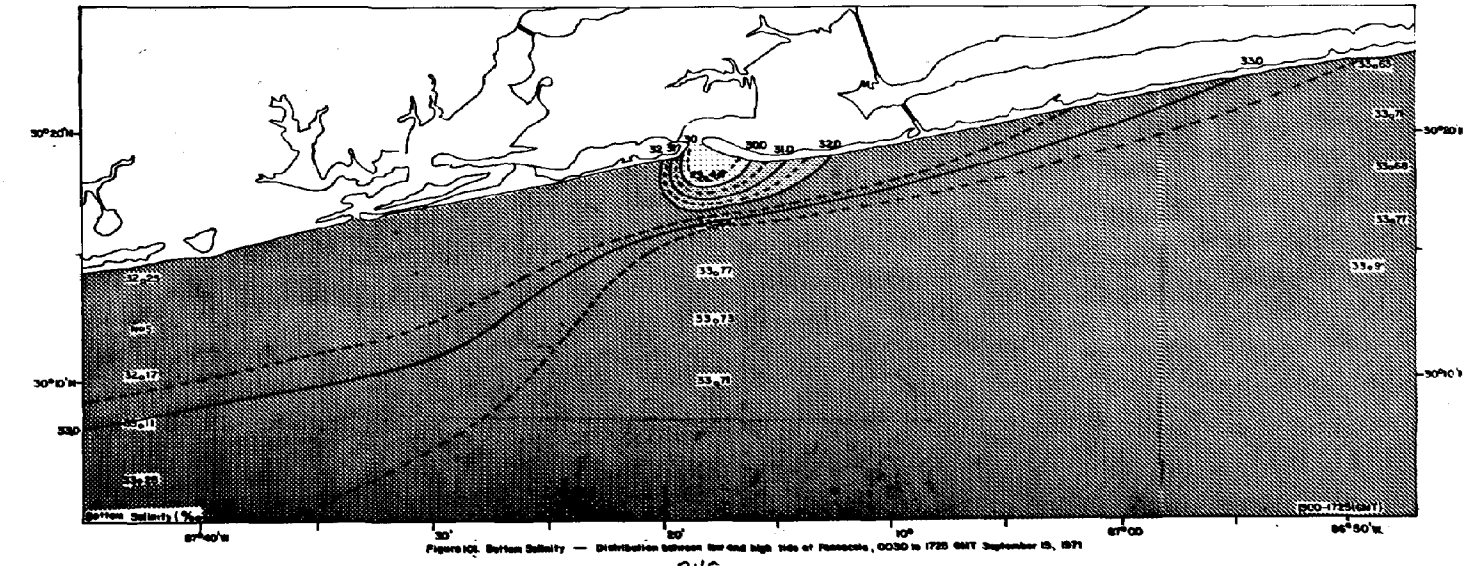


Figure 103. Bottom Salinity — Distribution between low and high tide at Pensacola, 0030 to 1725 GMT September 15, 1971

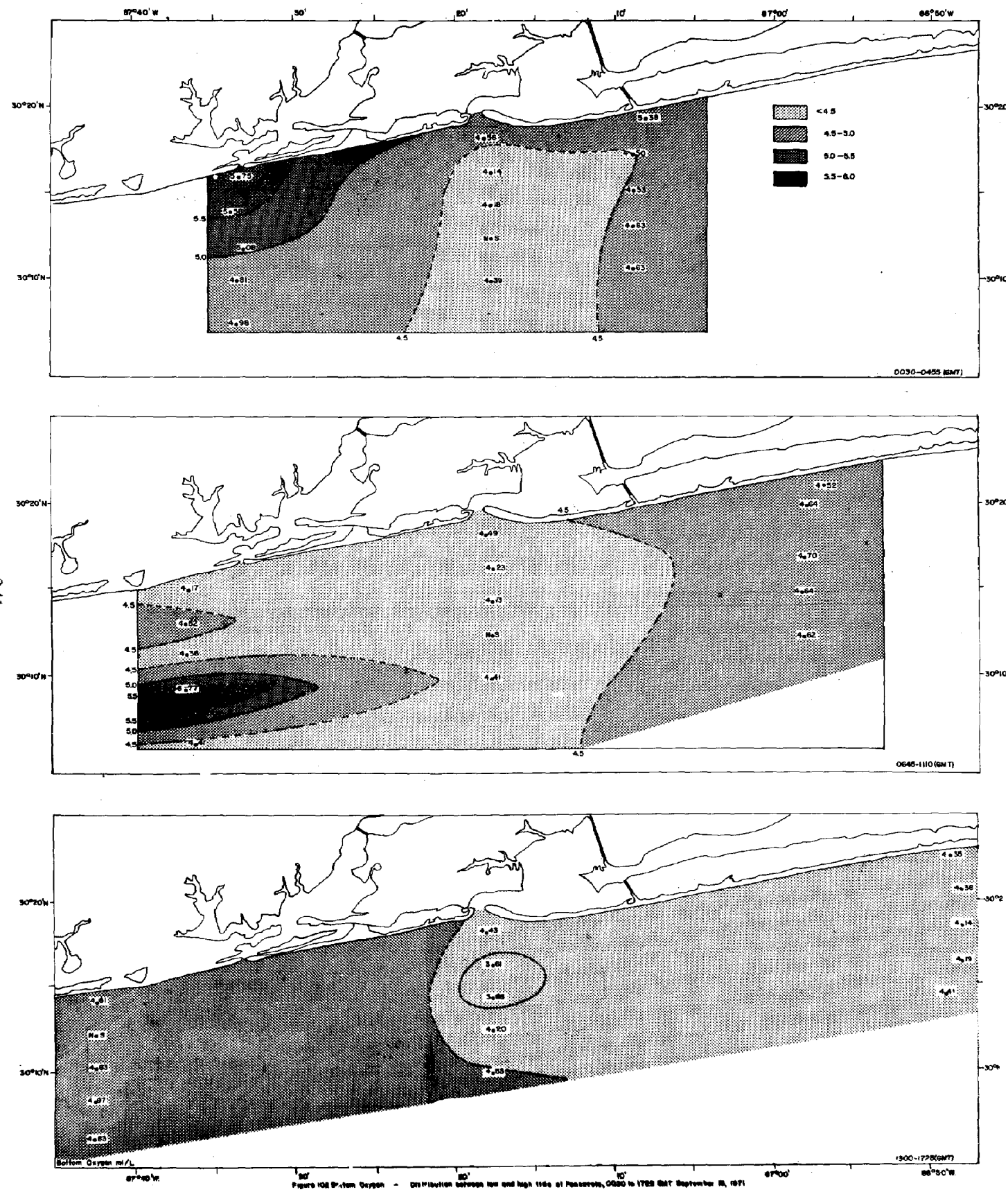


Figure 102 Bottom Oxygen - Distribution between low and high tides at Pensacola, 0030 to 1725 GMT September 16, 1971

< 0.04
0.04 - 0.08
0.08 - 0.16
0.16 - 0.32
> 0.32
0930-0455(GMT)
0645-1110(GMT)
1300-1725(GMT)
87°50'W
87°40'W
87°00
10'
20'
30'
30°20'N
30°10'N
30°20'
30°10'

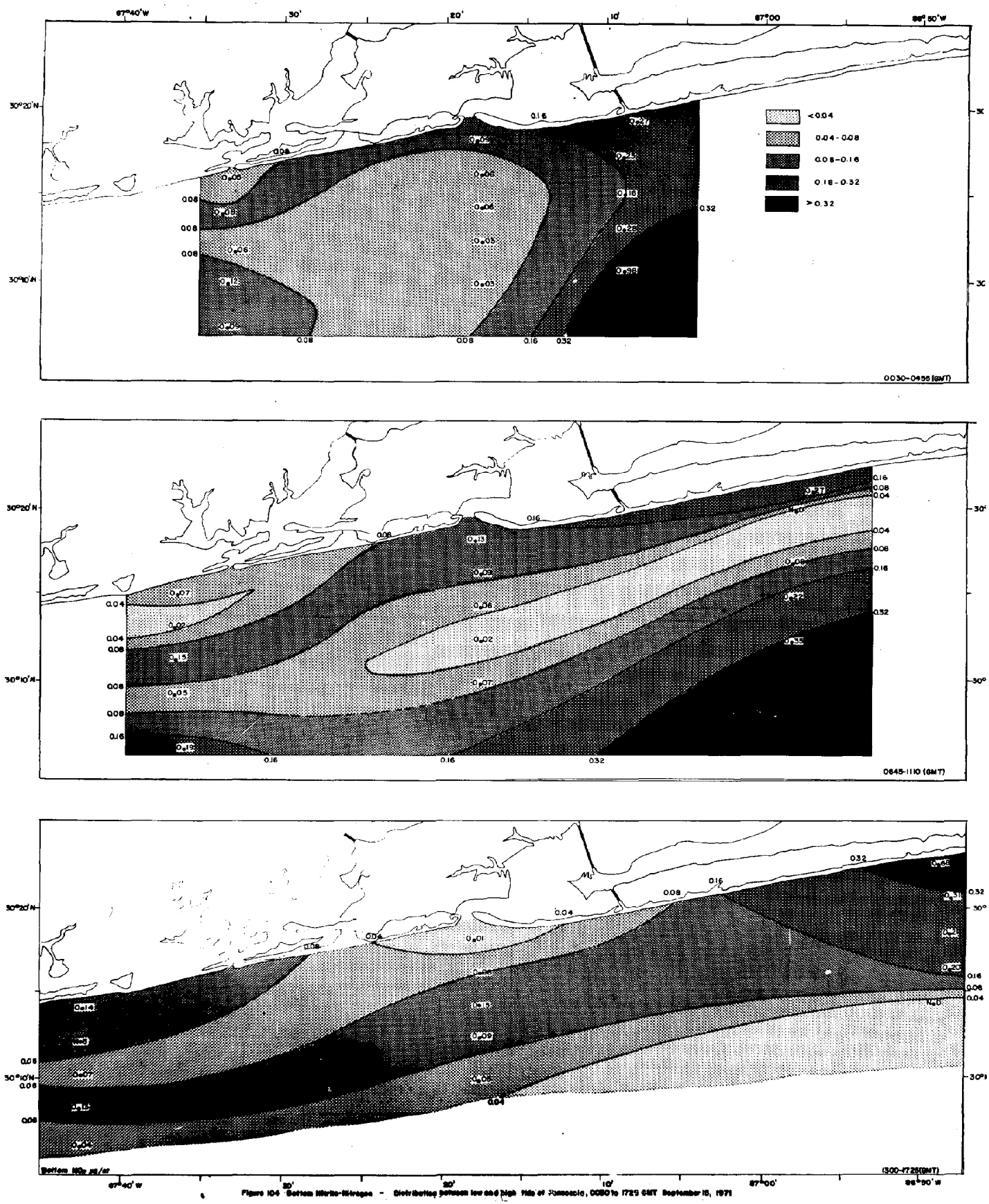


Figure 104 - Bottom Nitrite-Nitrogen - Distribution between low and high tide at Pensacola, 0030 to 1725 GMT September 15, 1971

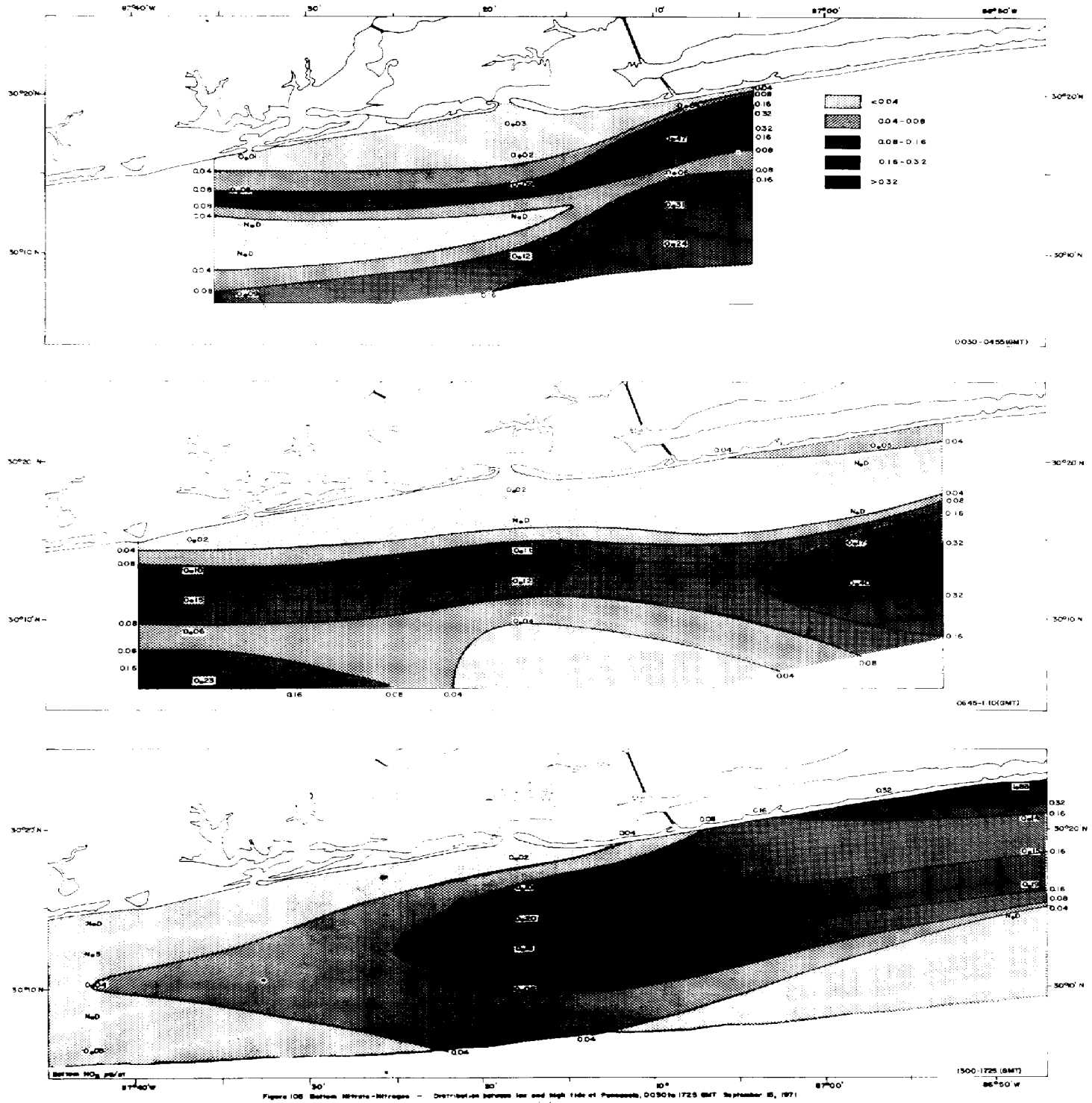


Figure 108 Bottom Nitrate-Nitrogen — Distribution between low and high tide at Pensacola, 0030 to 1725 GMT September 15, 1971

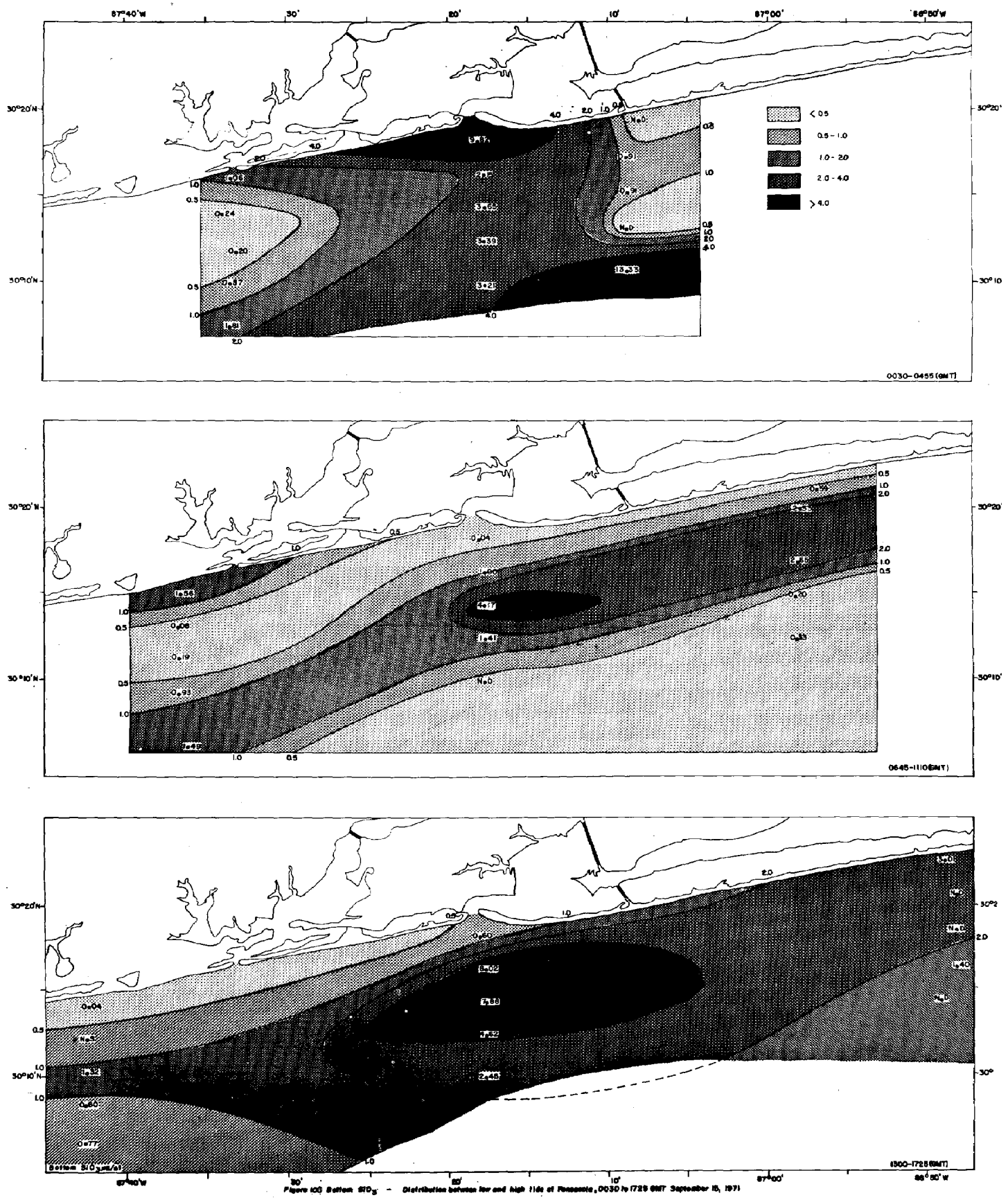


Figure 100 Bottom SiO_3 - Distribution between low and high tide at Pensacola, 0030 to 1725 GMT September 15, 1971

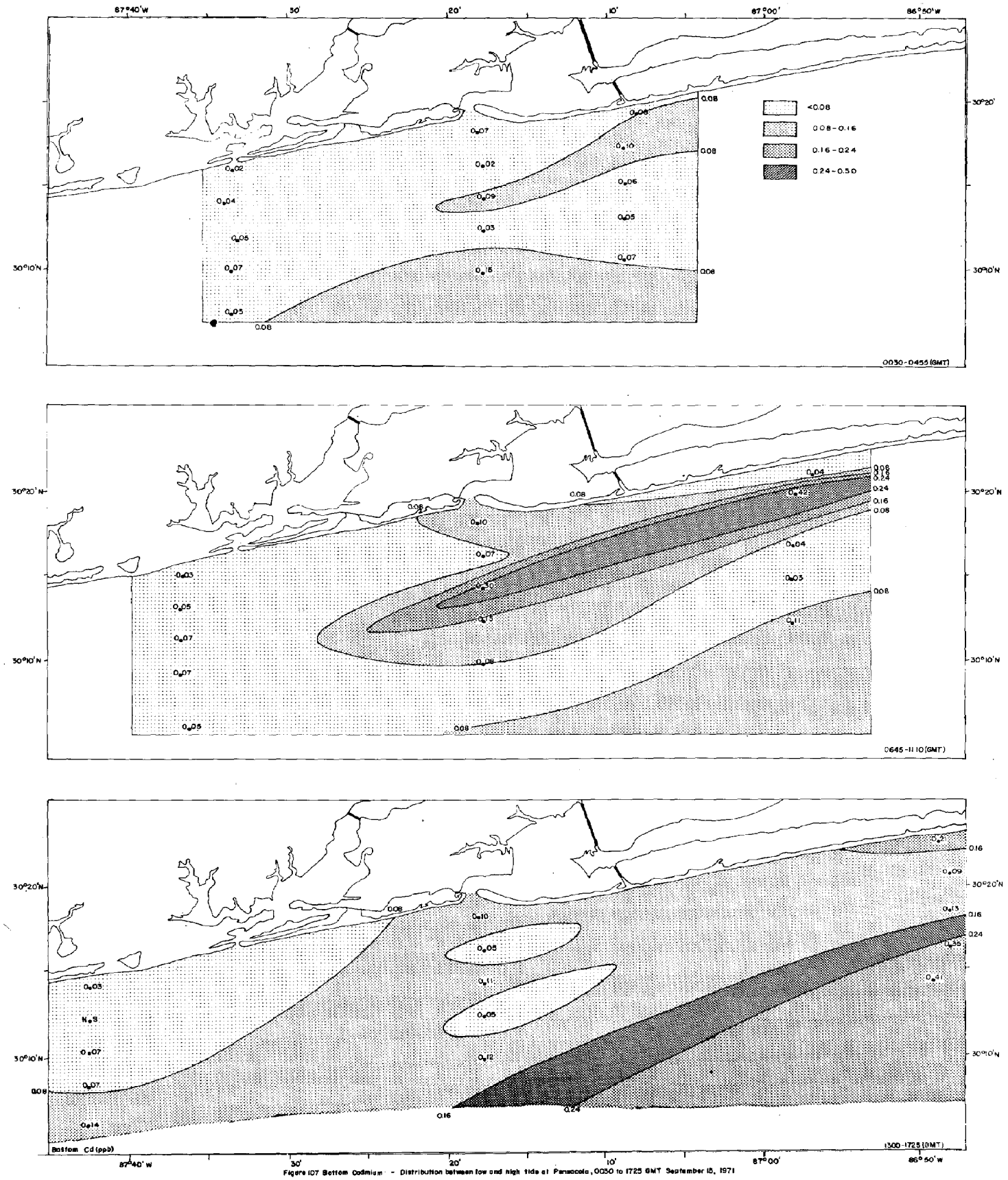


Figure 107 Bottom Cadmium - Distribution between low and high tide at Pensacola, 0030 to 1725 GMT September 15, 1971

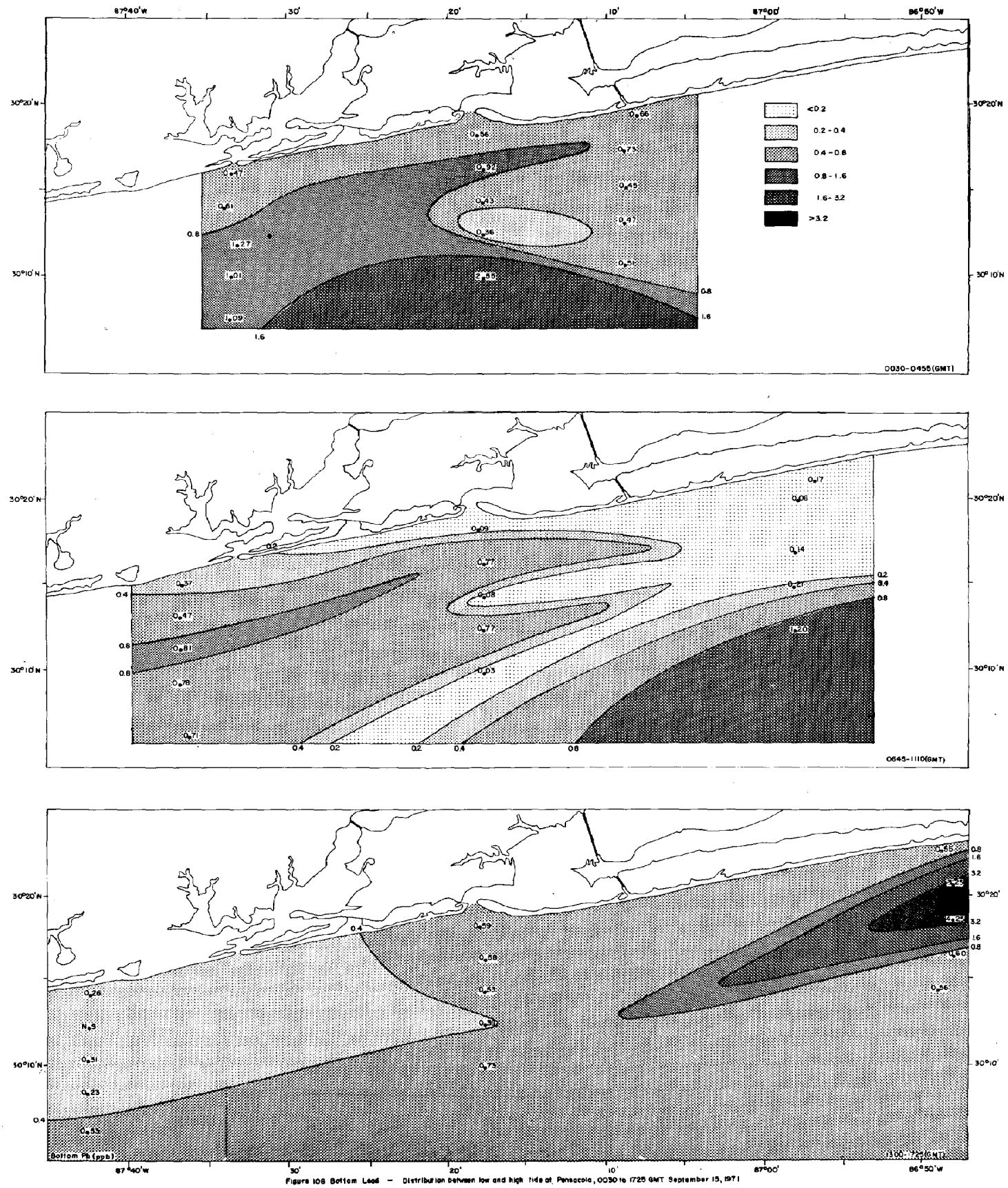
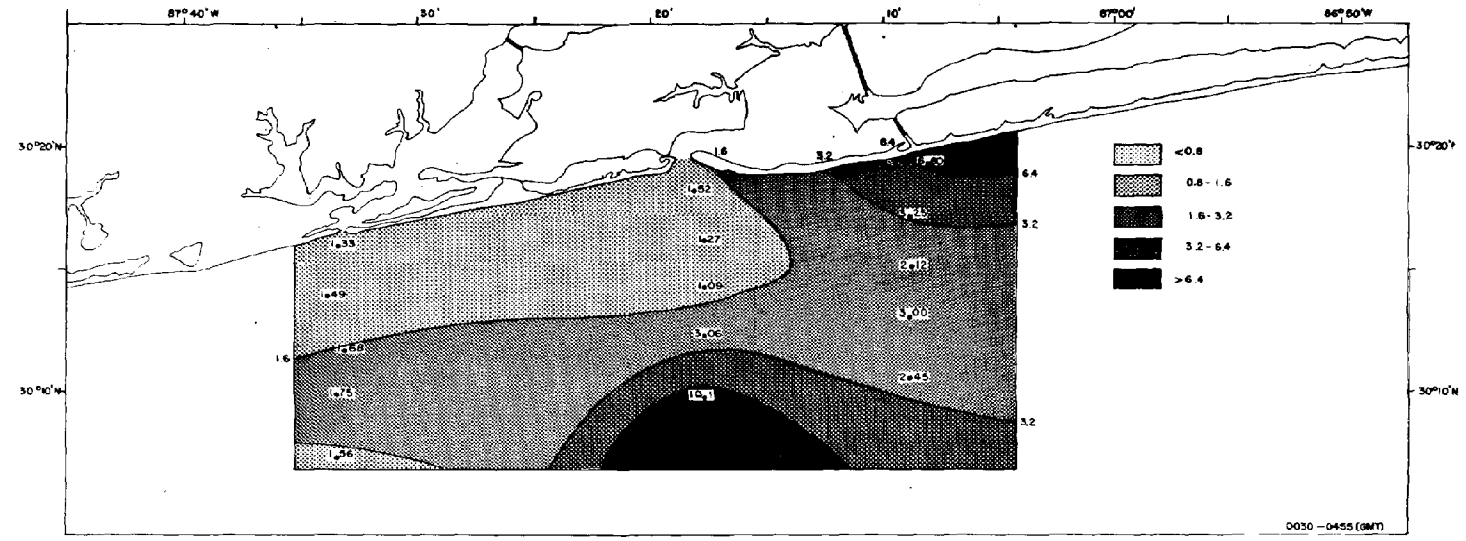
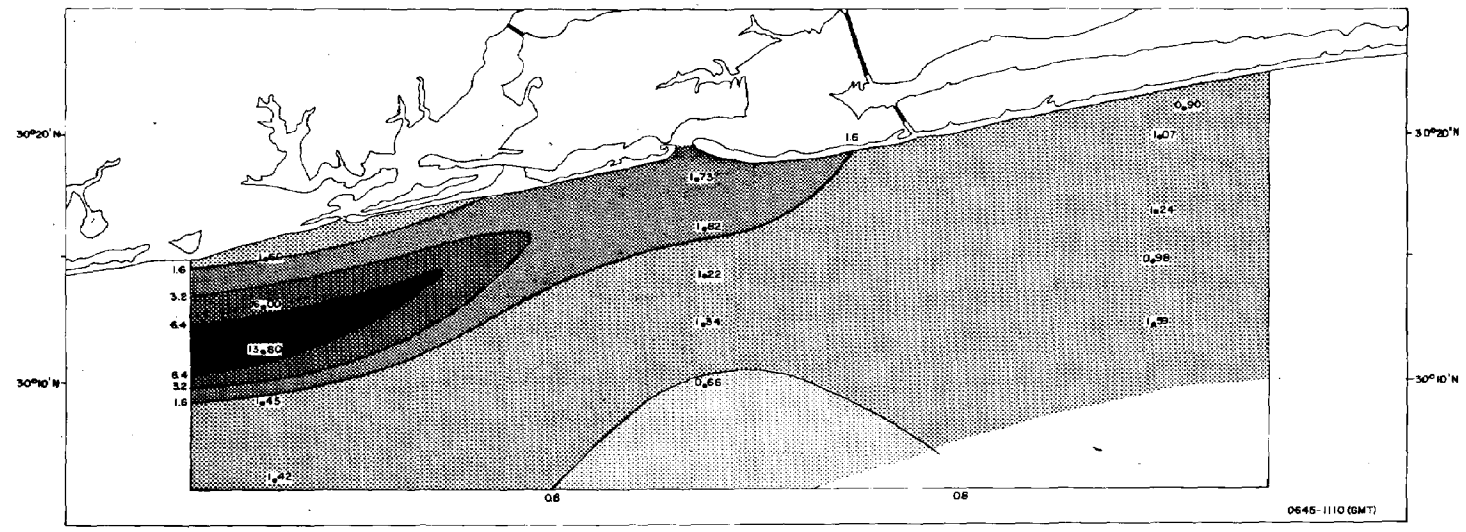


Figure 108 Bottom Lead — Distribution between low and high tide at Pensacola, 0030 to 1725 GMT September 15, 1971





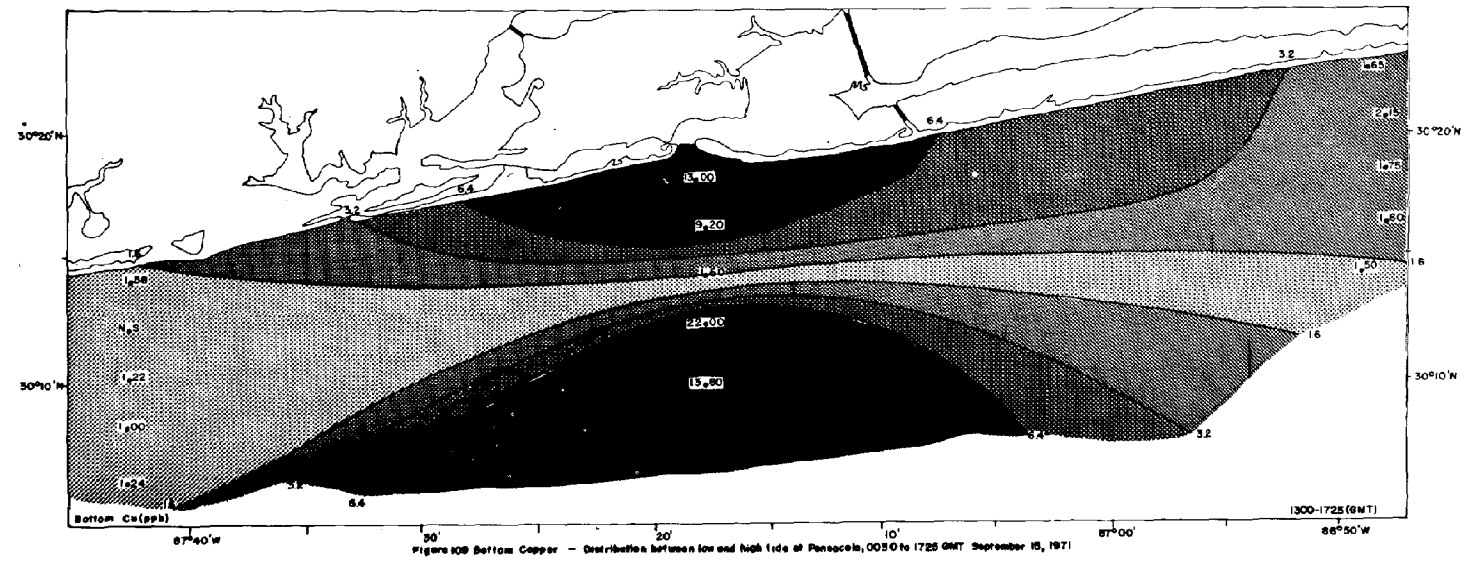


Figure 109 Bottom Copper – Distribution between low and high tide at Pensacola, 0030 to 1725 GMT September 15, 1971

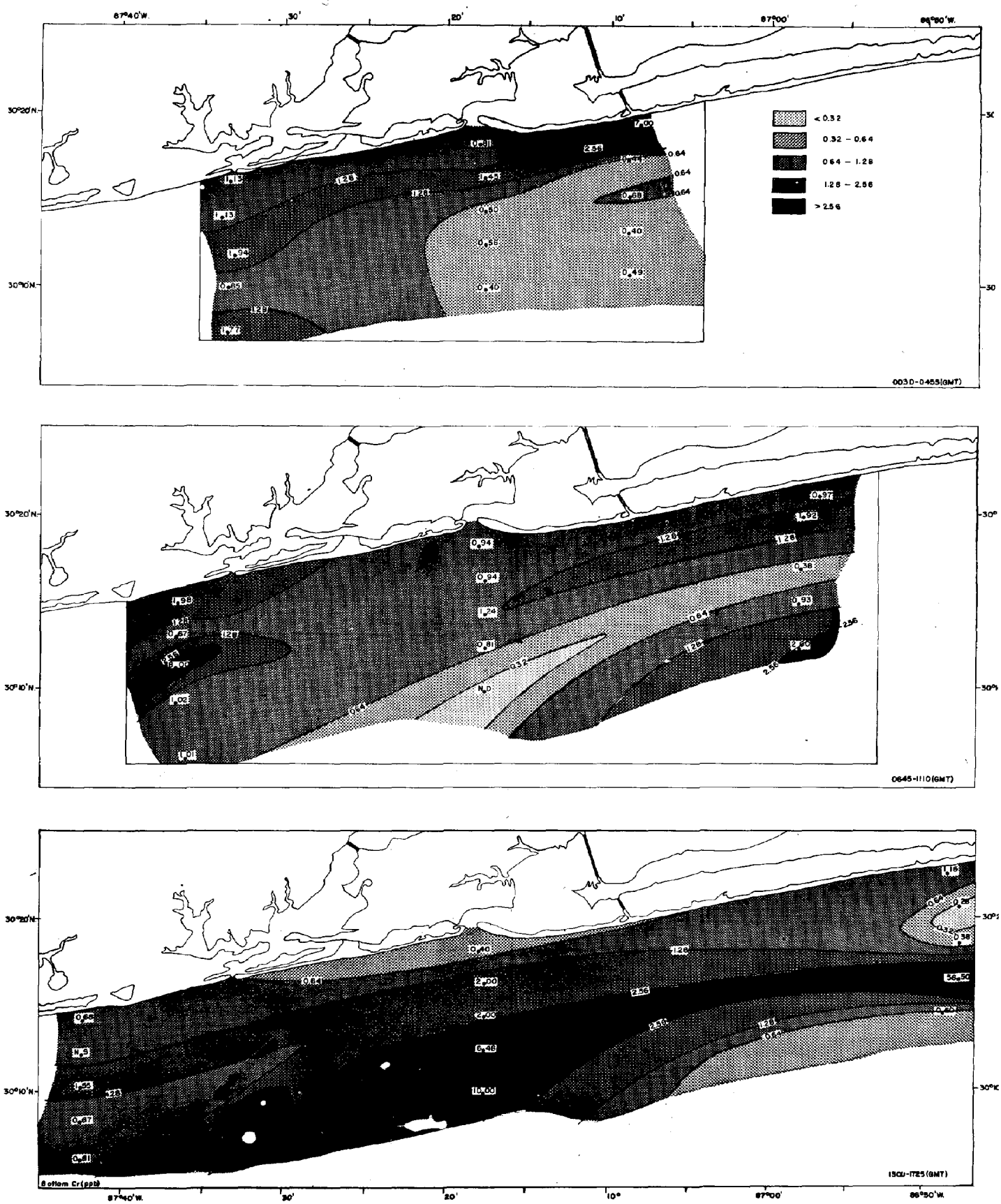


Figure 110 Bottom Chromium - Distribution between low and high tide at Pensacola, 0030 to 1725 GMT September 15, 1971

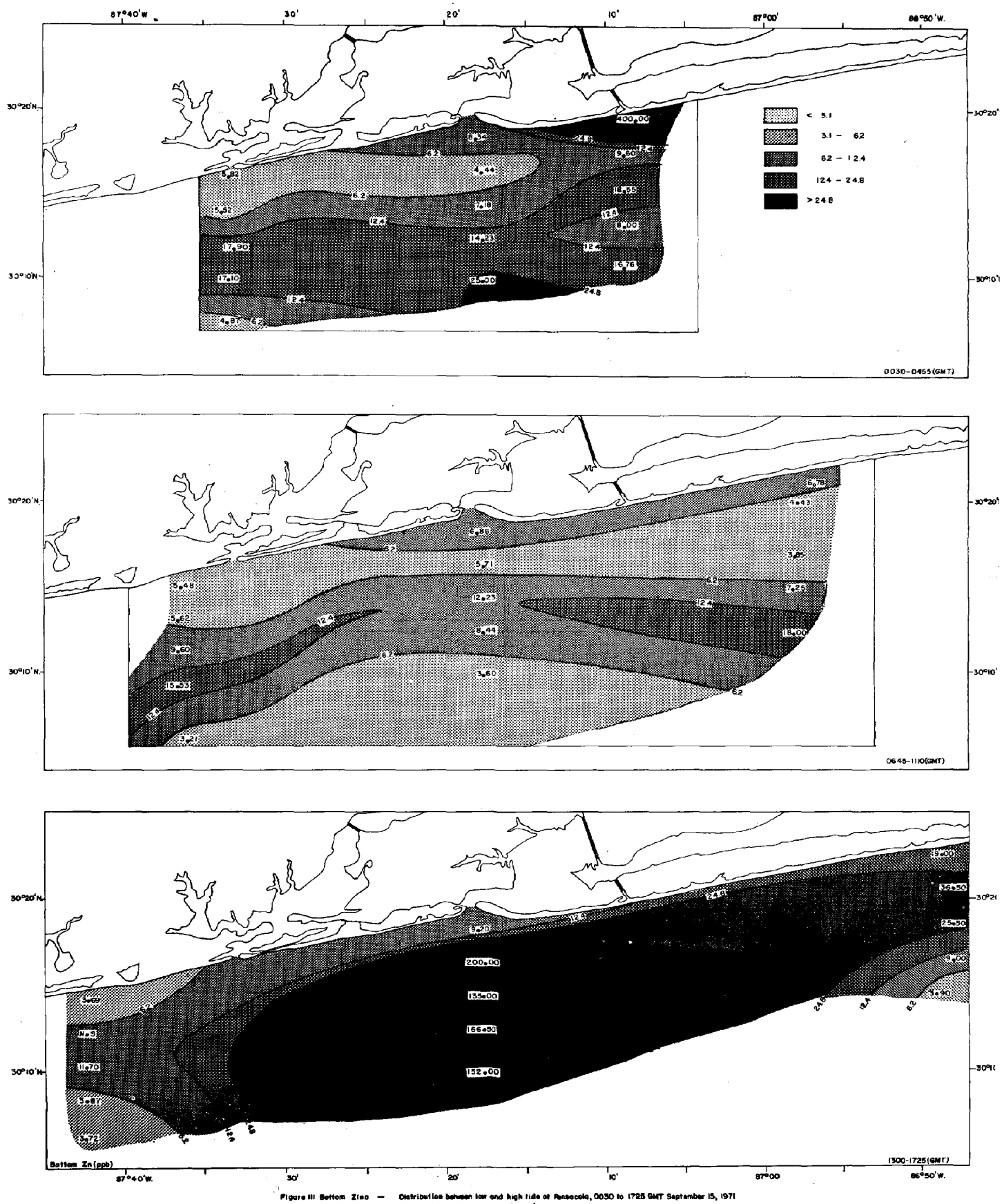


Figure III Bottom Zinc — Distribution between low and high tide at Pensacola, 0030 to 1725 GMT September 15, 1971

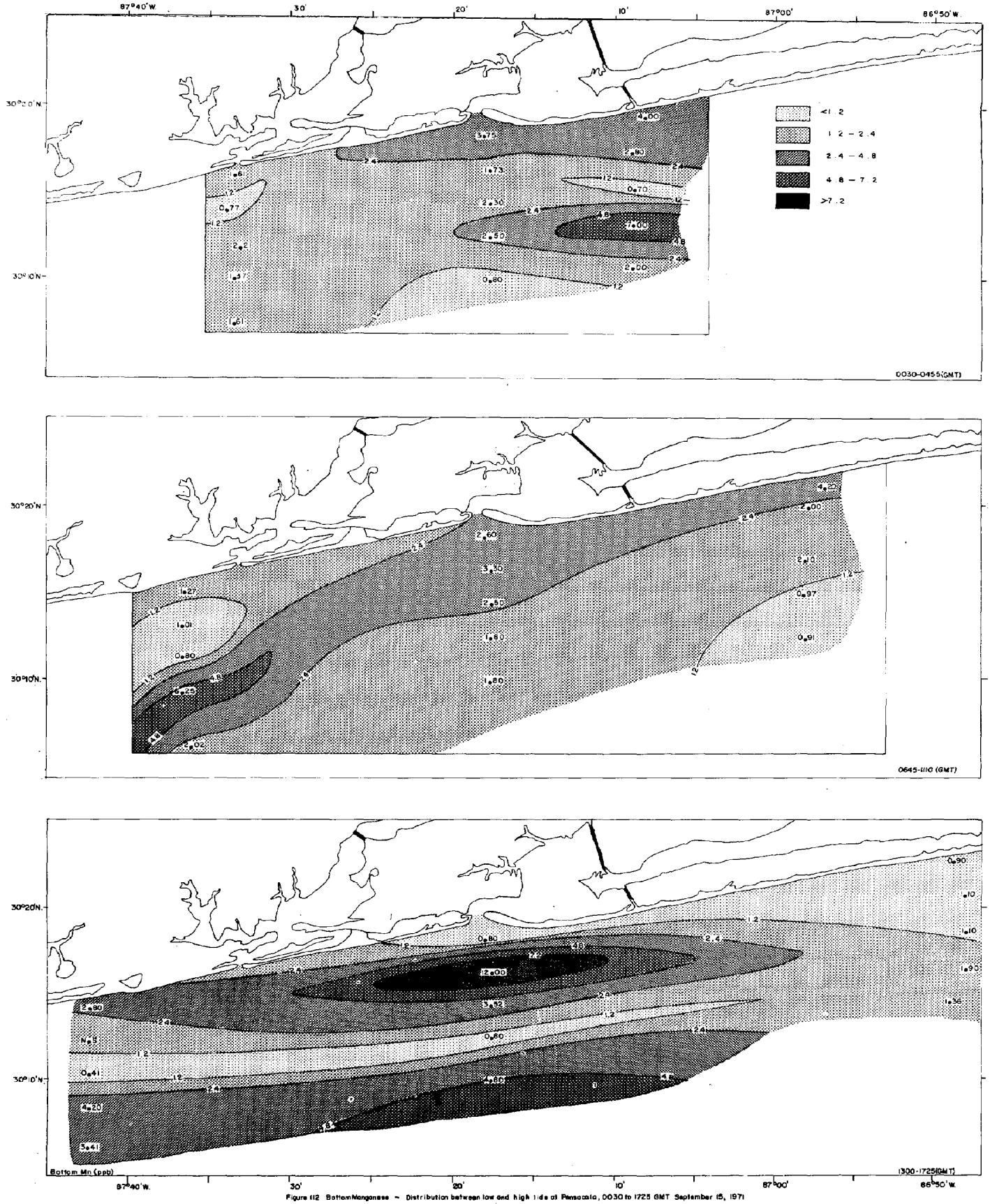


Figure 112 Bottom Manganese – Distribution between low and high tide at Pensacola, 0030 to 1725 GMT September 15, 1971

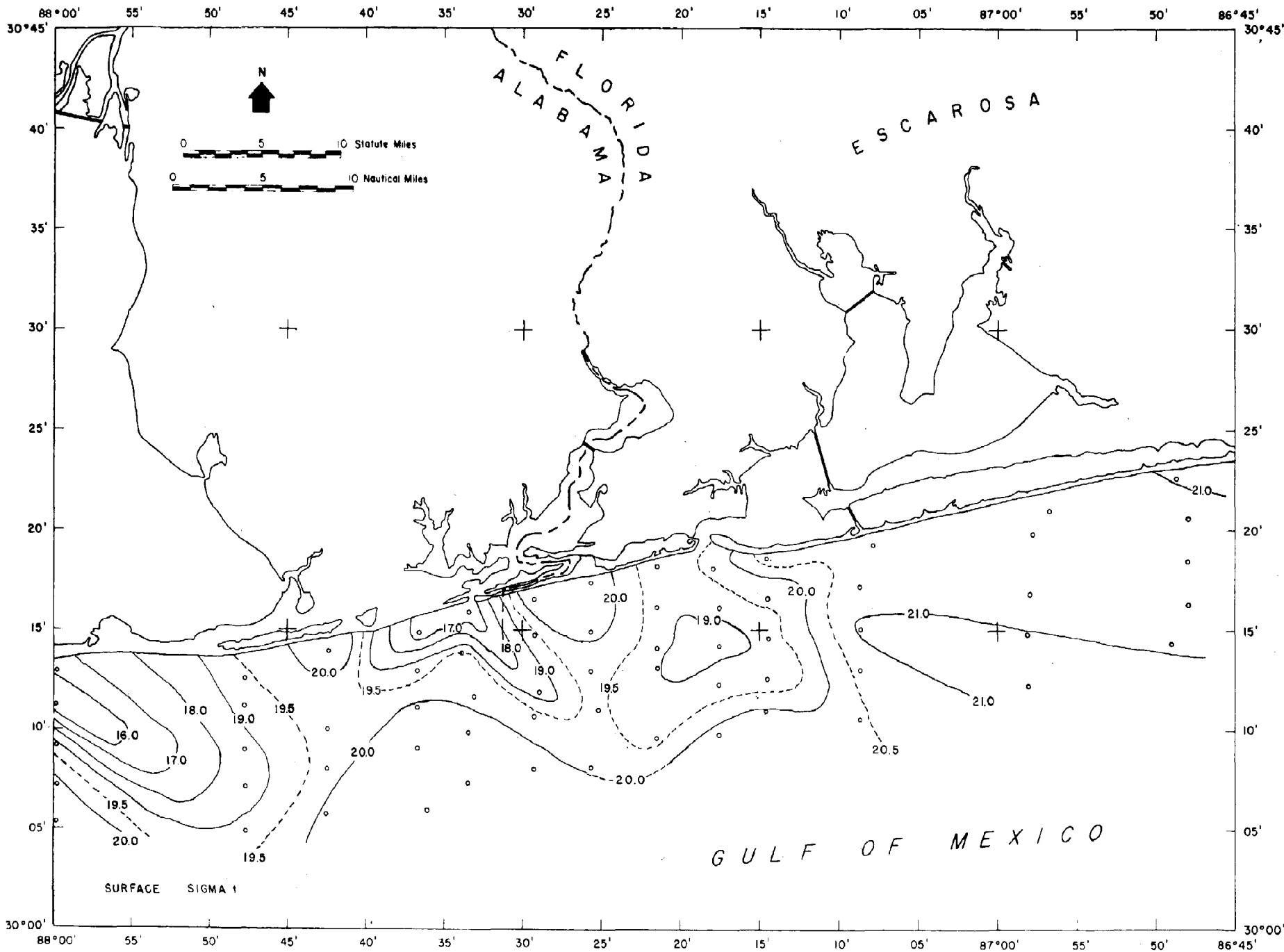


Figure 113 Surface Sigma t Distribution - September 14-16, 1971

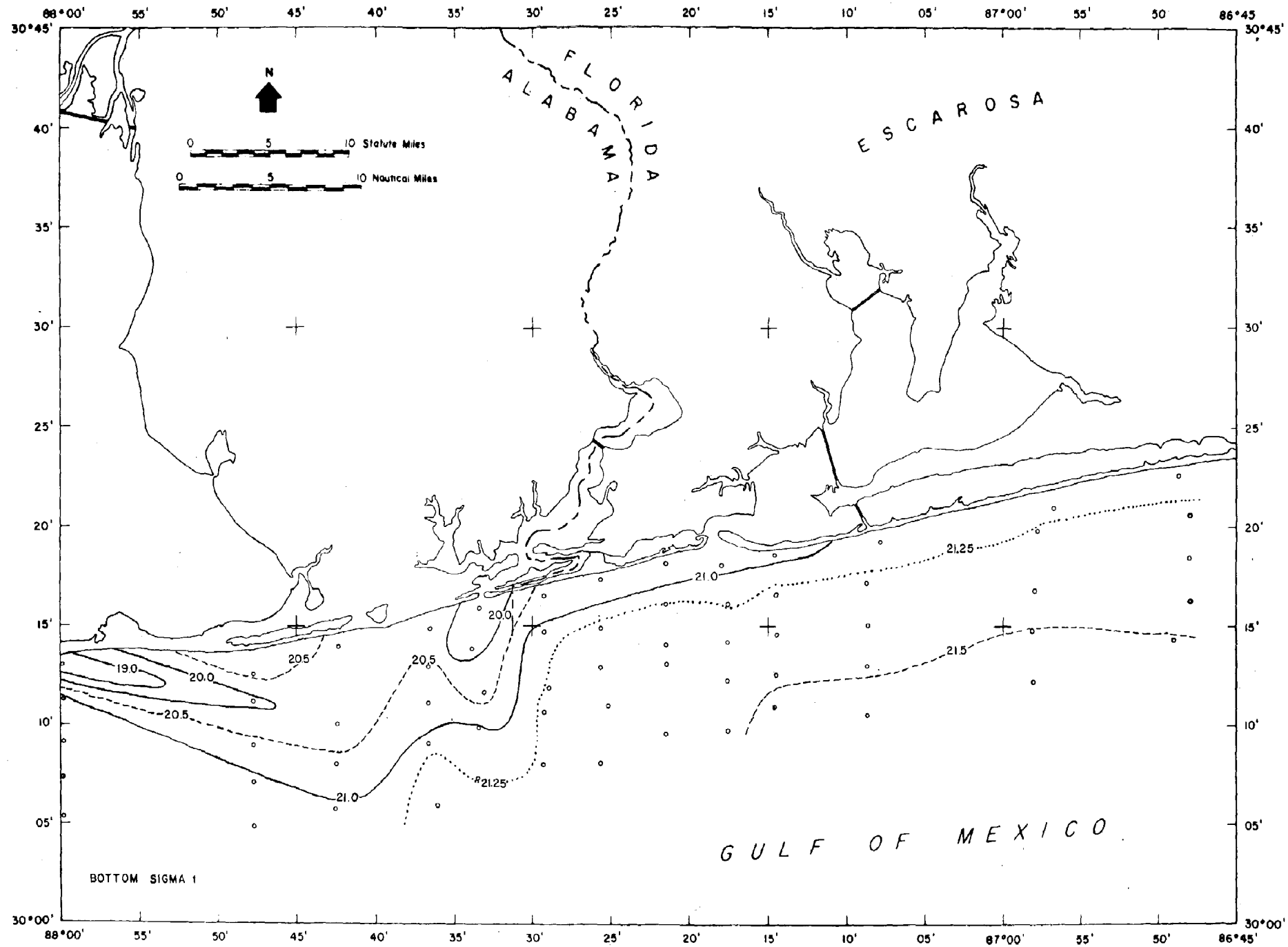


Figure 114 Bottom Sigma t Distribution - September 14-16, 1971

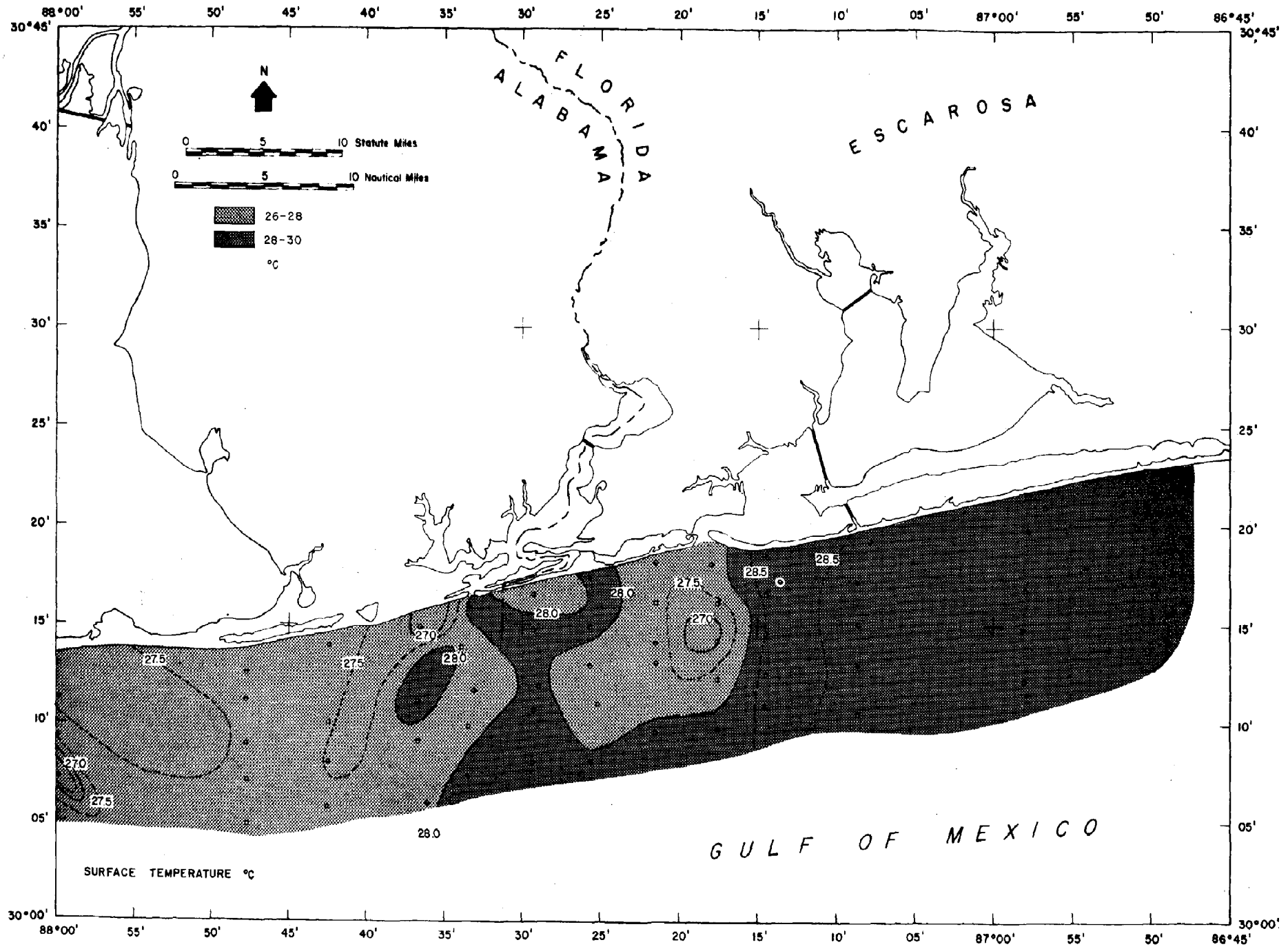


Figure 115 Surface Temperature Distribution — September 14-16, 1971

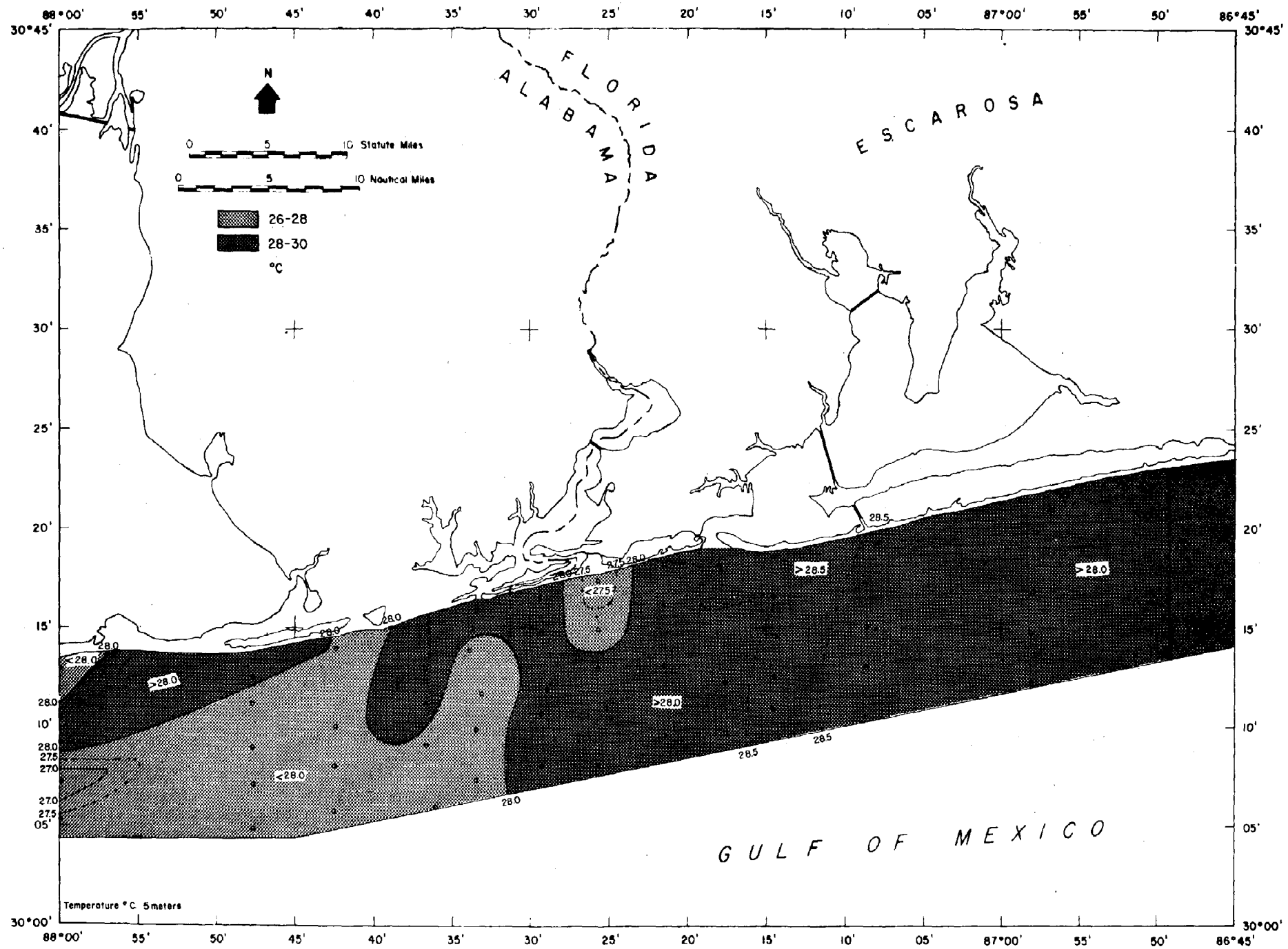


Figure 116 Temperature Distribution at Standard Depth 5 meters - September 14-16, 1971

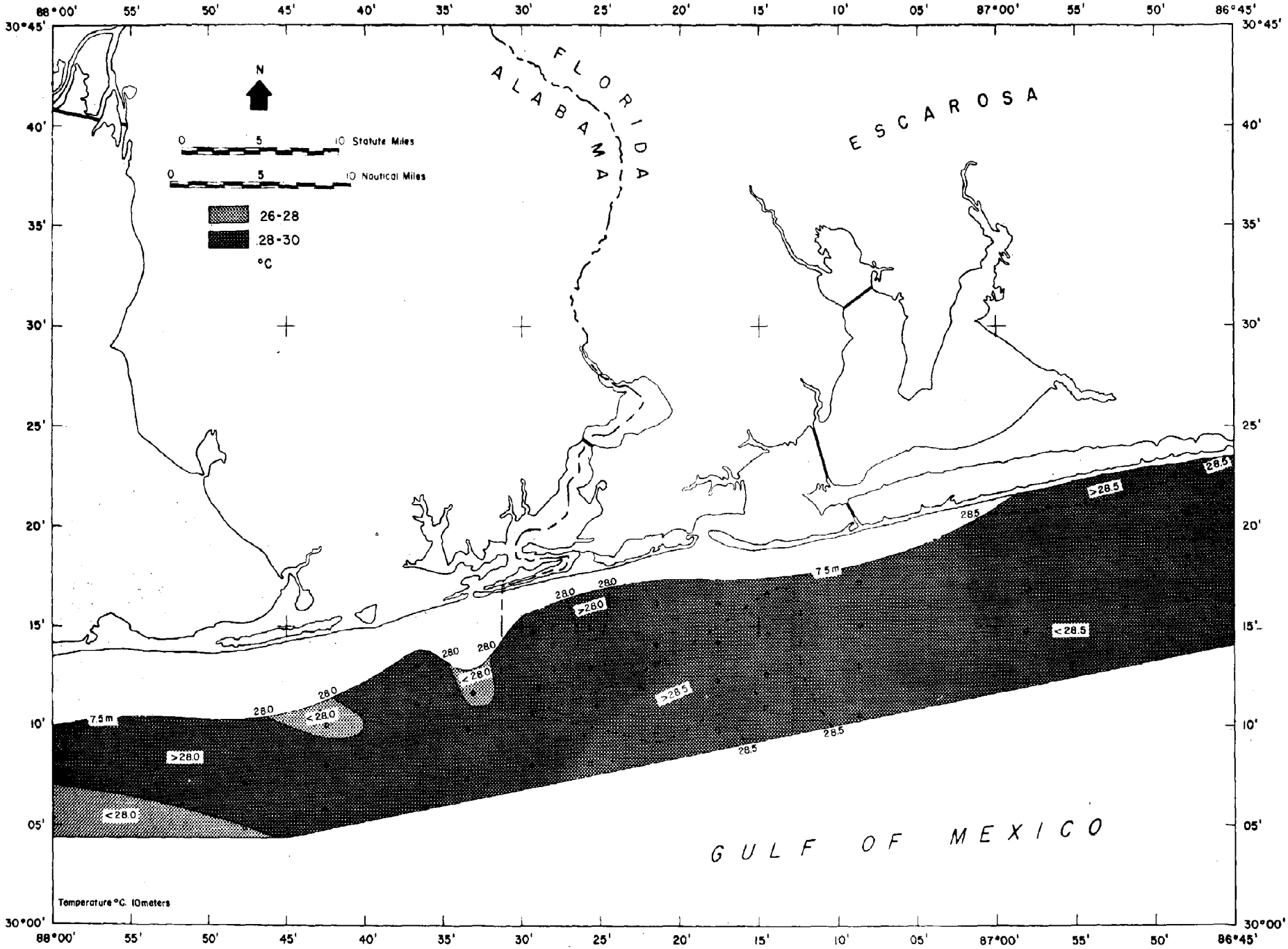


Figure 117 Temperature Distribution at Standard Depth 10 meters - September 14-16, 1971

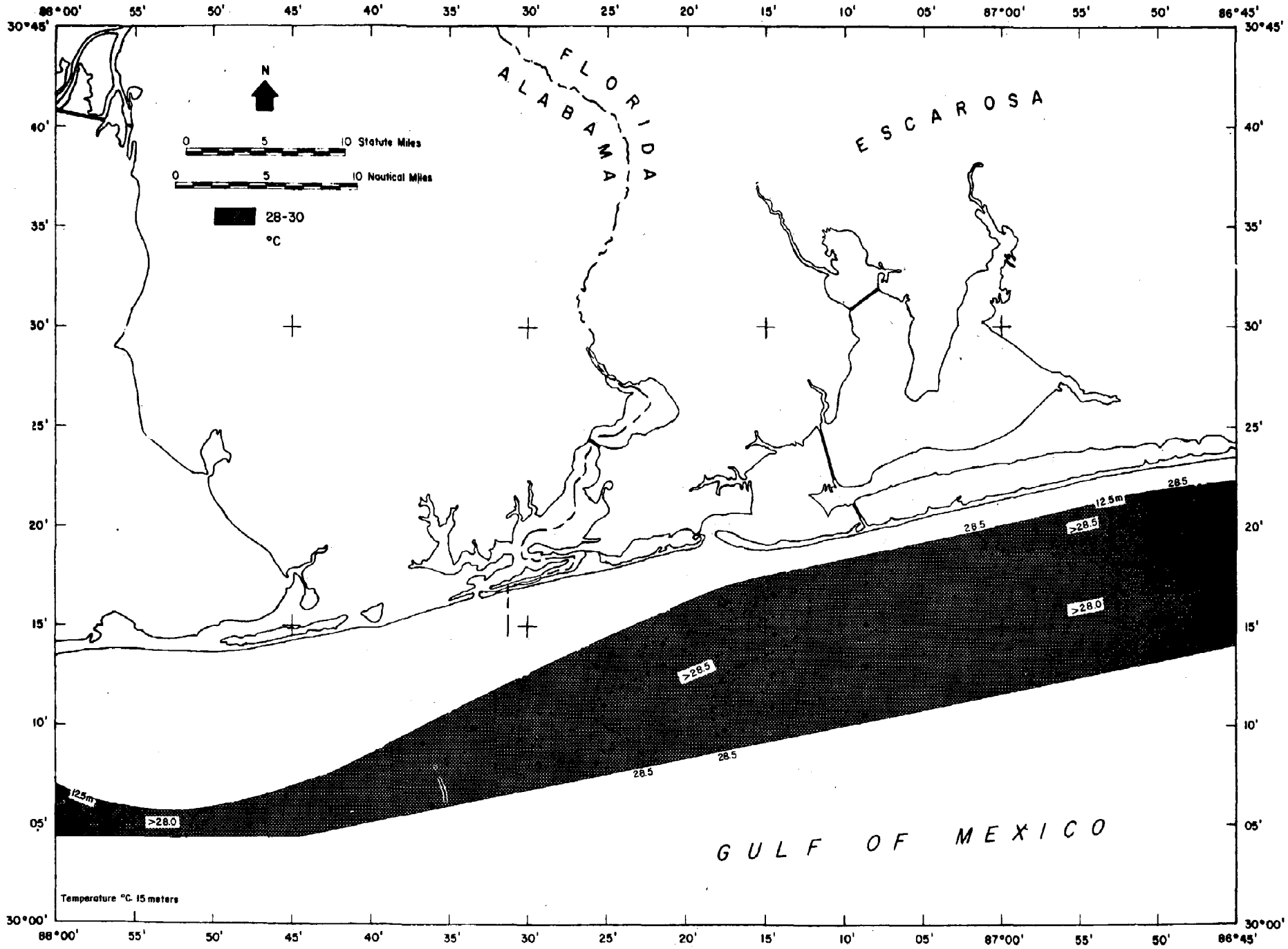


Figure 118 Temperature Distribution at Standard Depth 15meters – September 14-16, 1971

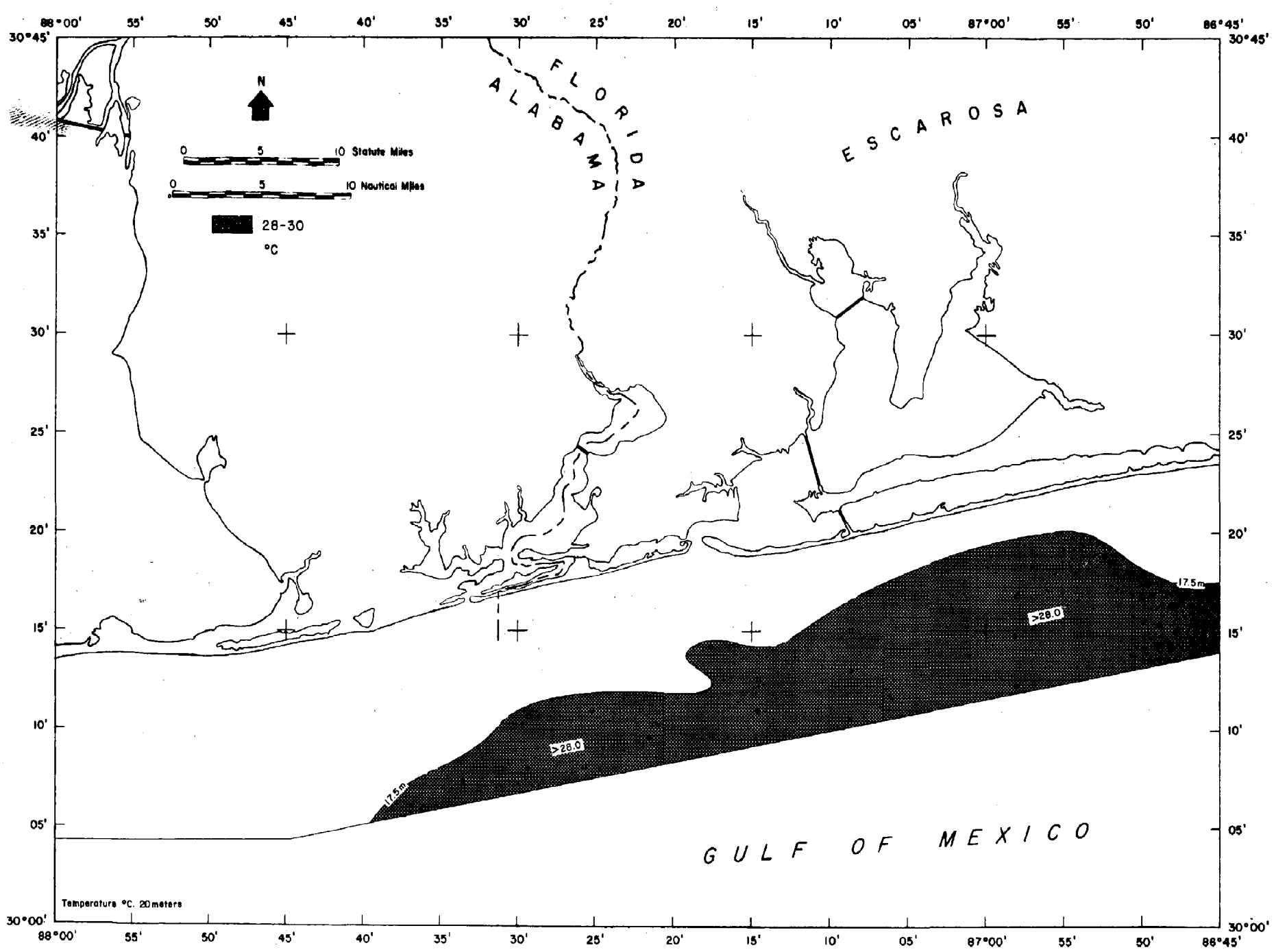


Figure 119 Temperature Distribution at Standard Depth 20 meters - September 14-16, 1971

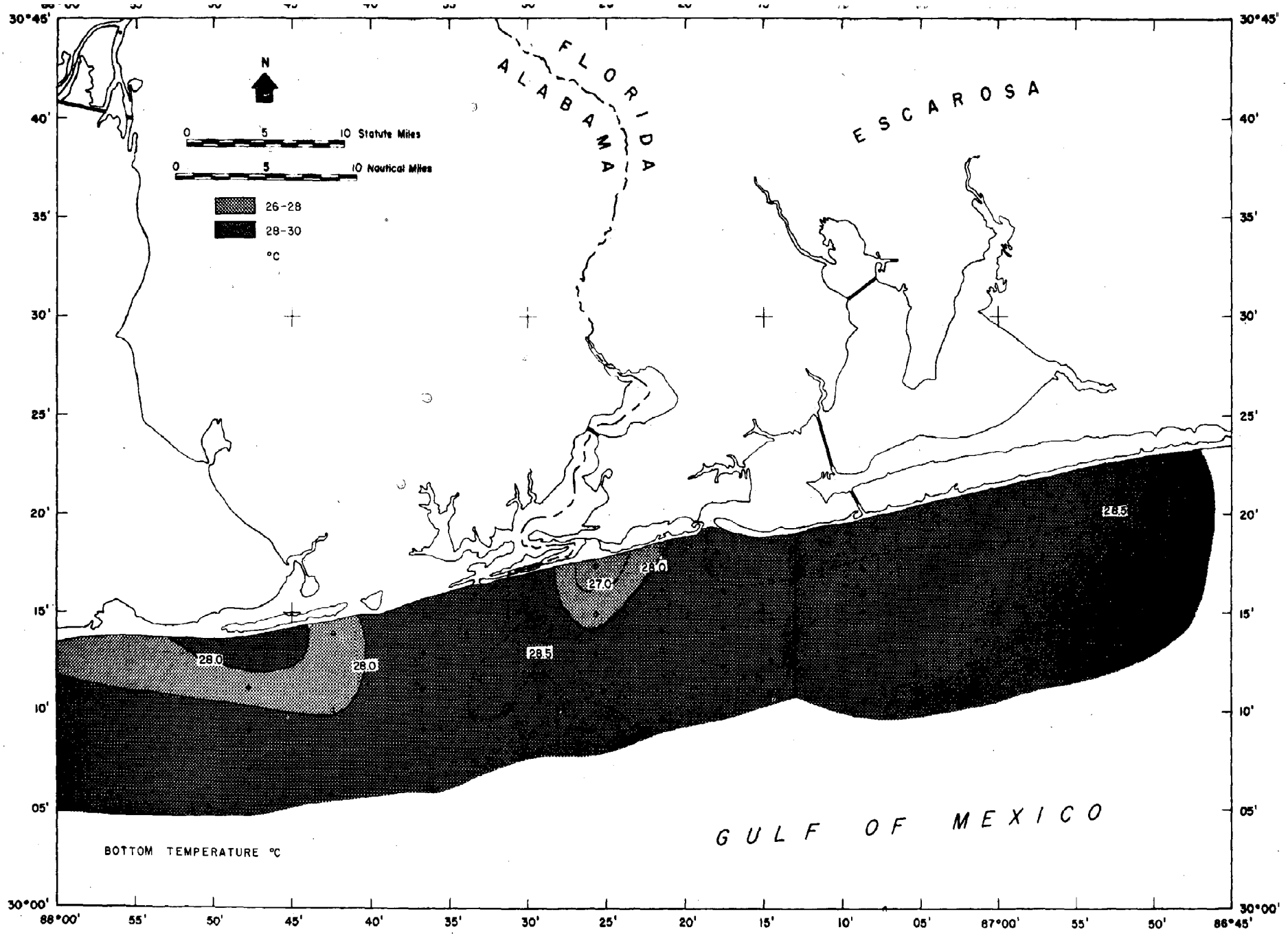


Figure 120 Bottom Temperature Distribution - September 14-16, 1971

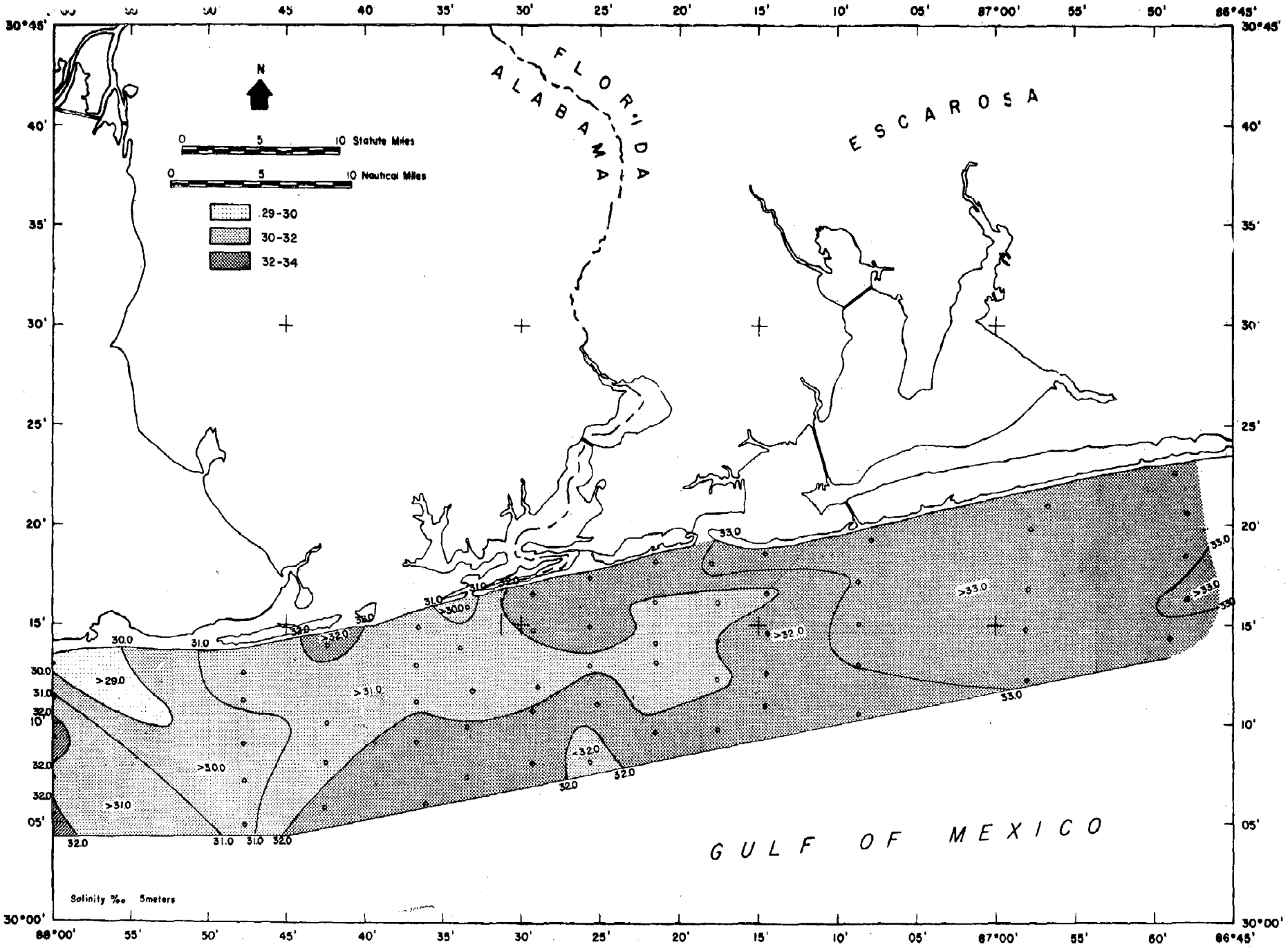


Figure 121 Salinity - Distribution ‰ at Standard Depth 5 meters - September 14-16, 1971

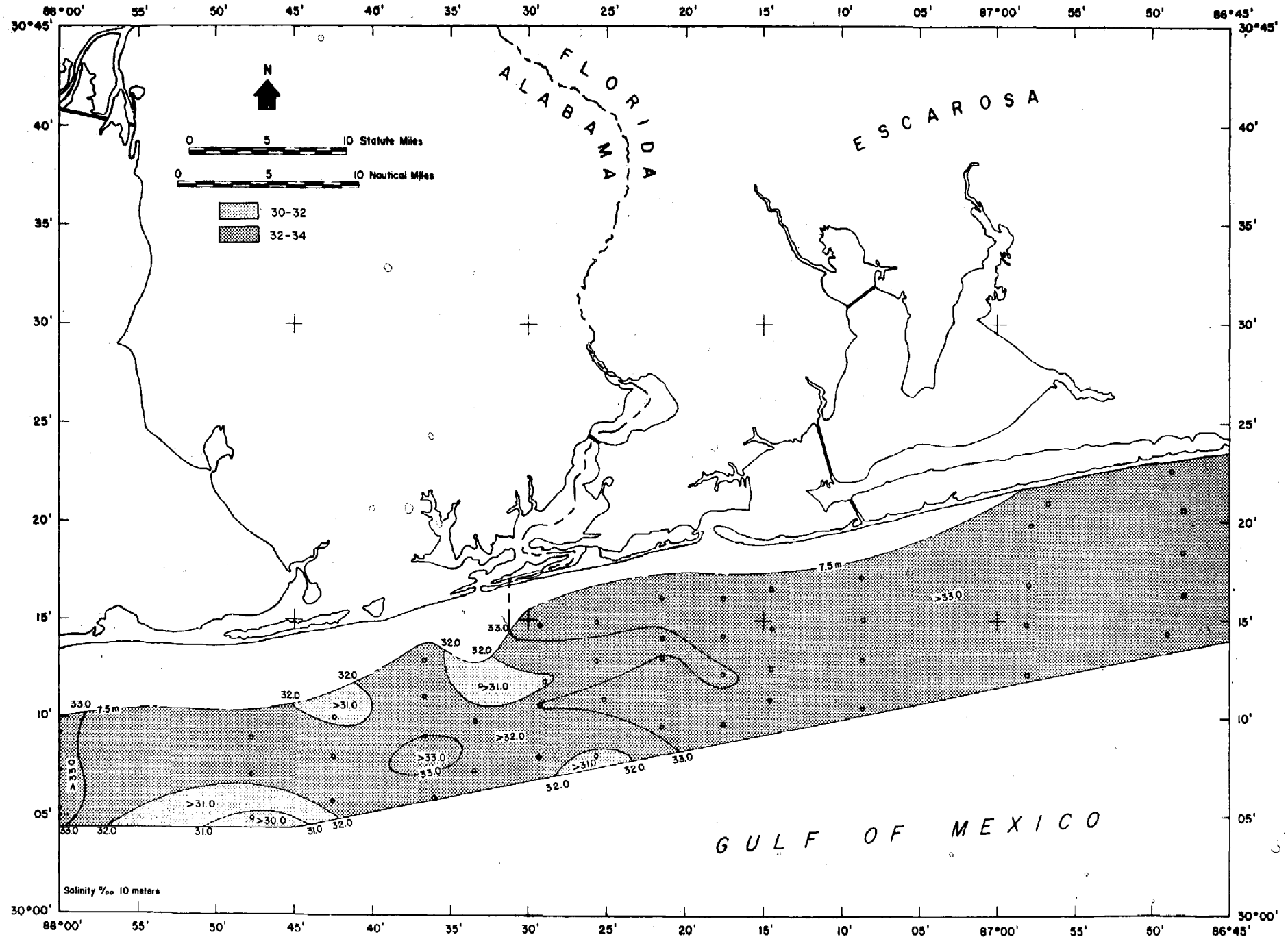


Figure 122 Salinity Distribution ‰ at Standard Depth 10 meters – September 14-16, 1971

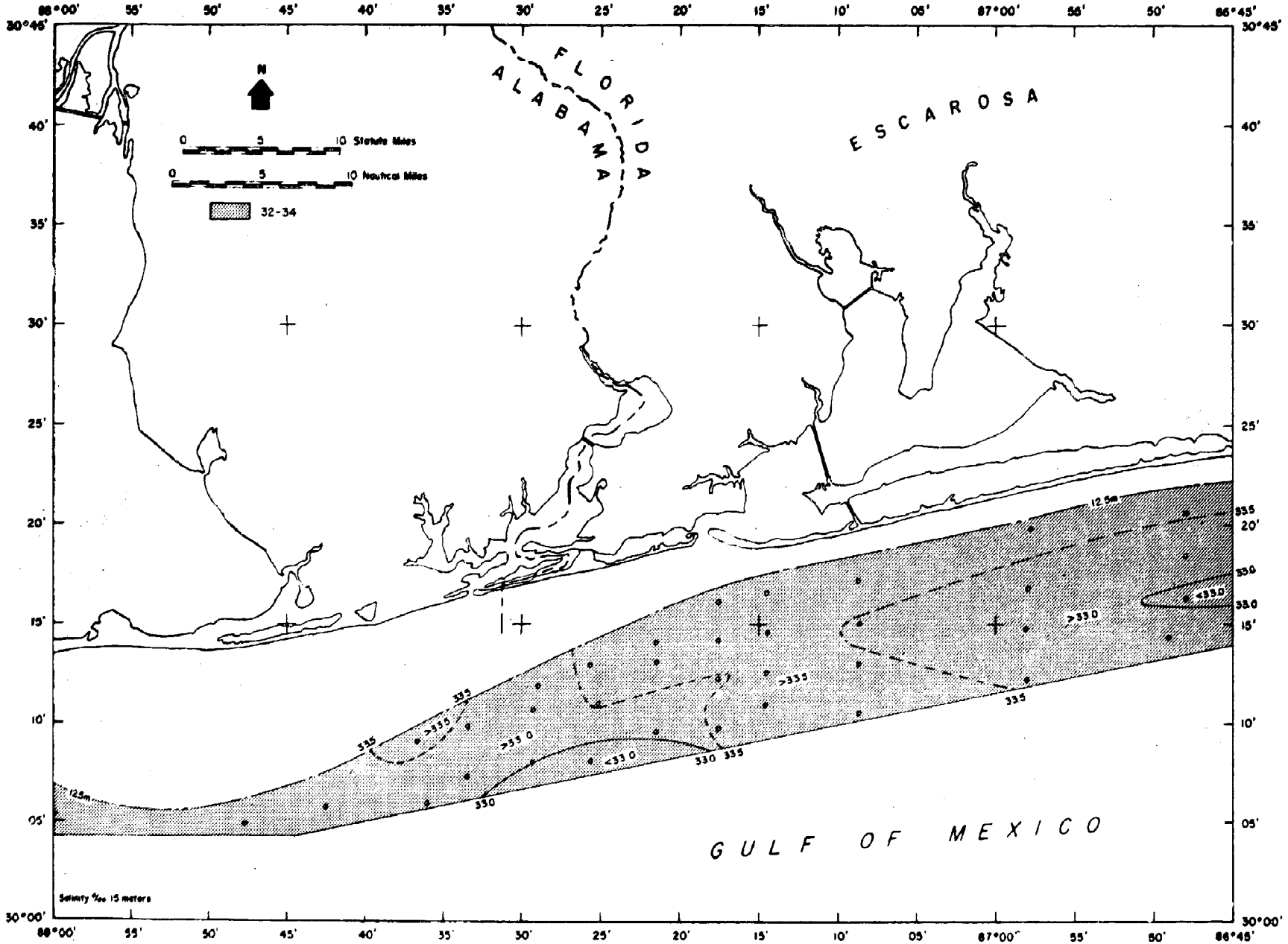


Figure 123 Salinity Distribution ‰ at Standard Depth 15 meters - September 14-16, 1971

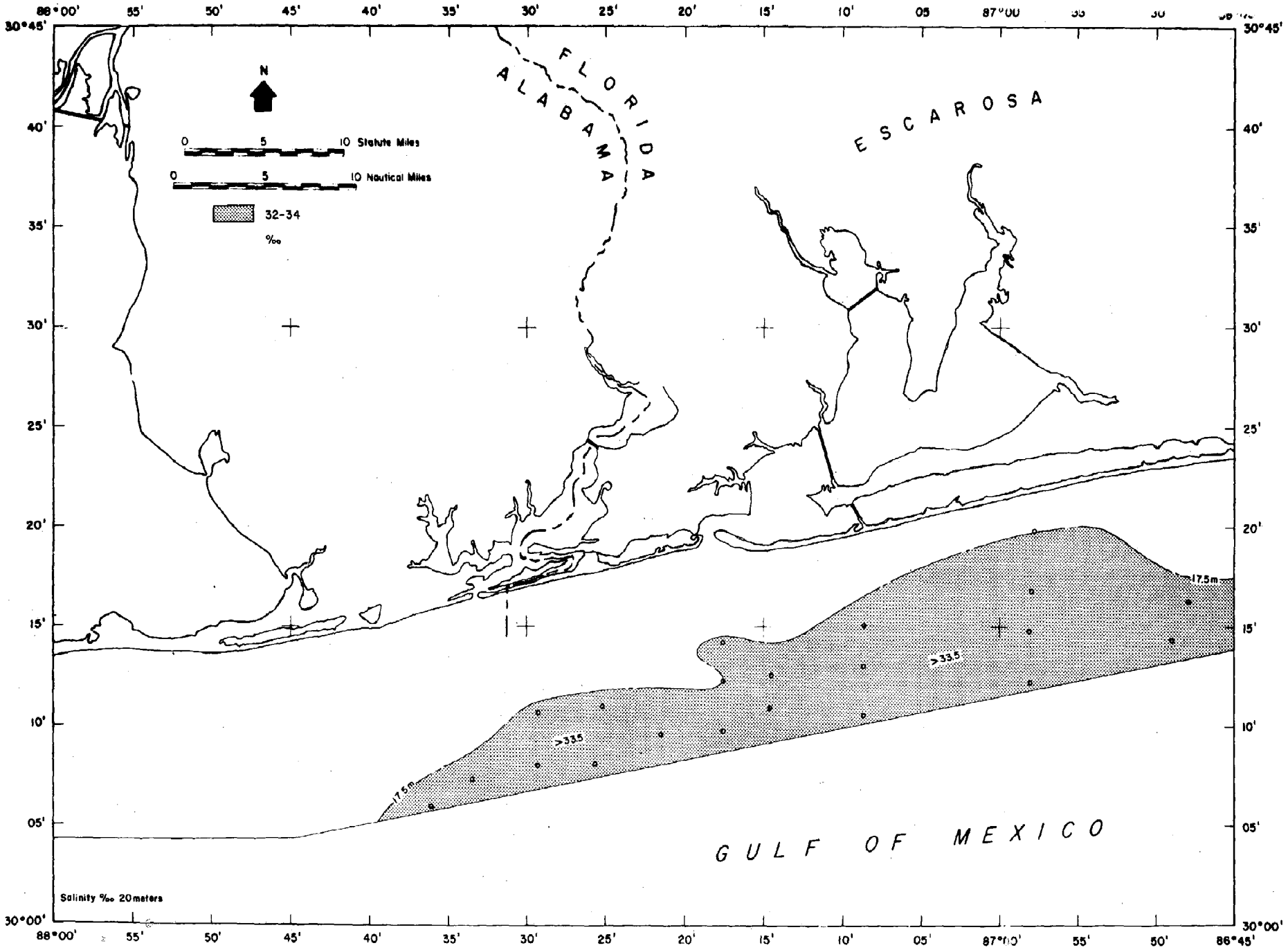


Figure 124 Salinity Distribution ‰ at Standard Depth 20 meters - September 14-16, 1971

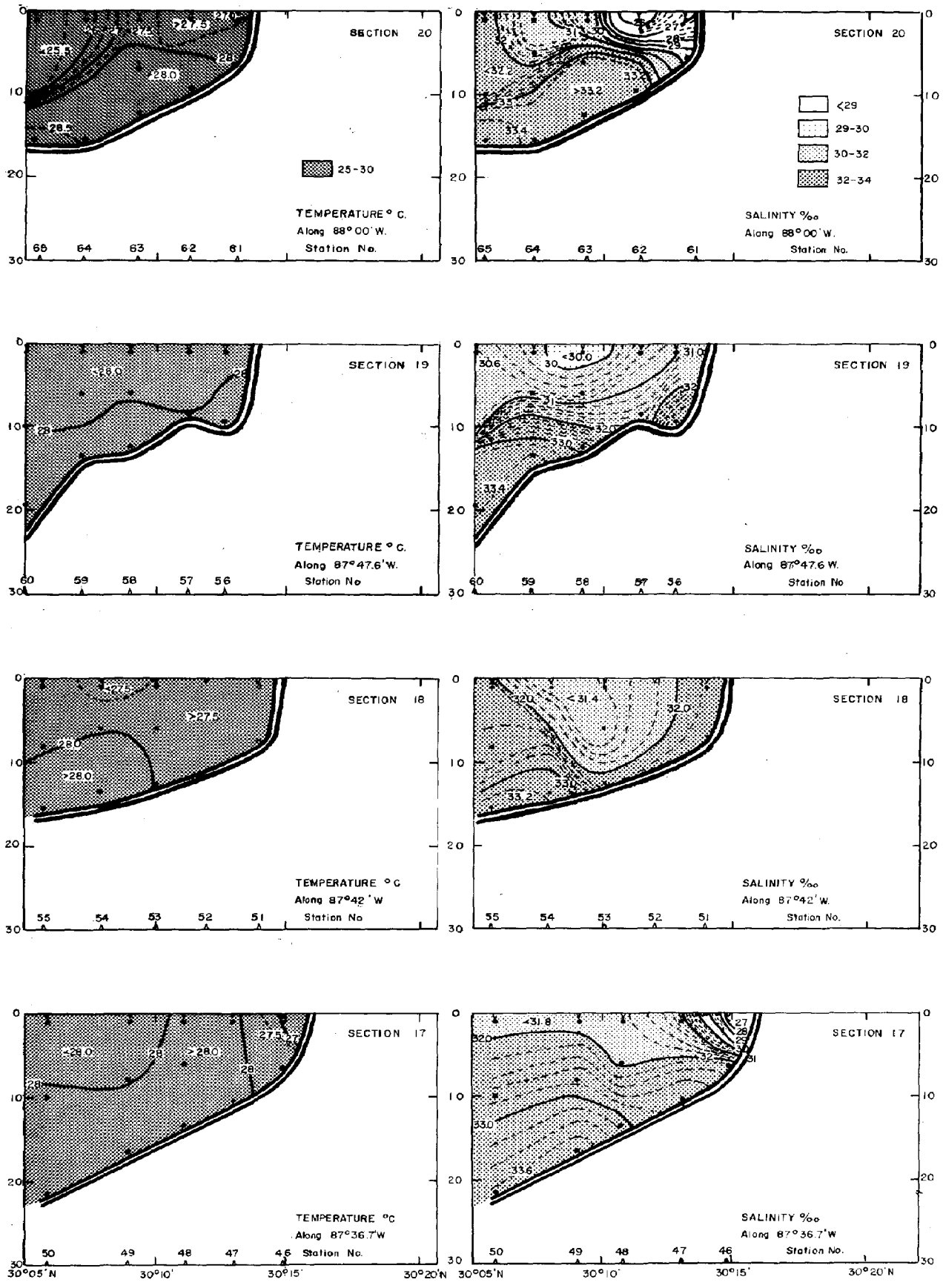


FIGURE 125 VERTICAL DISTRIBUTION TEMPERATURE AND SALINITY - ESCAROSA I. - SEPTEMBER 14-16, 1971

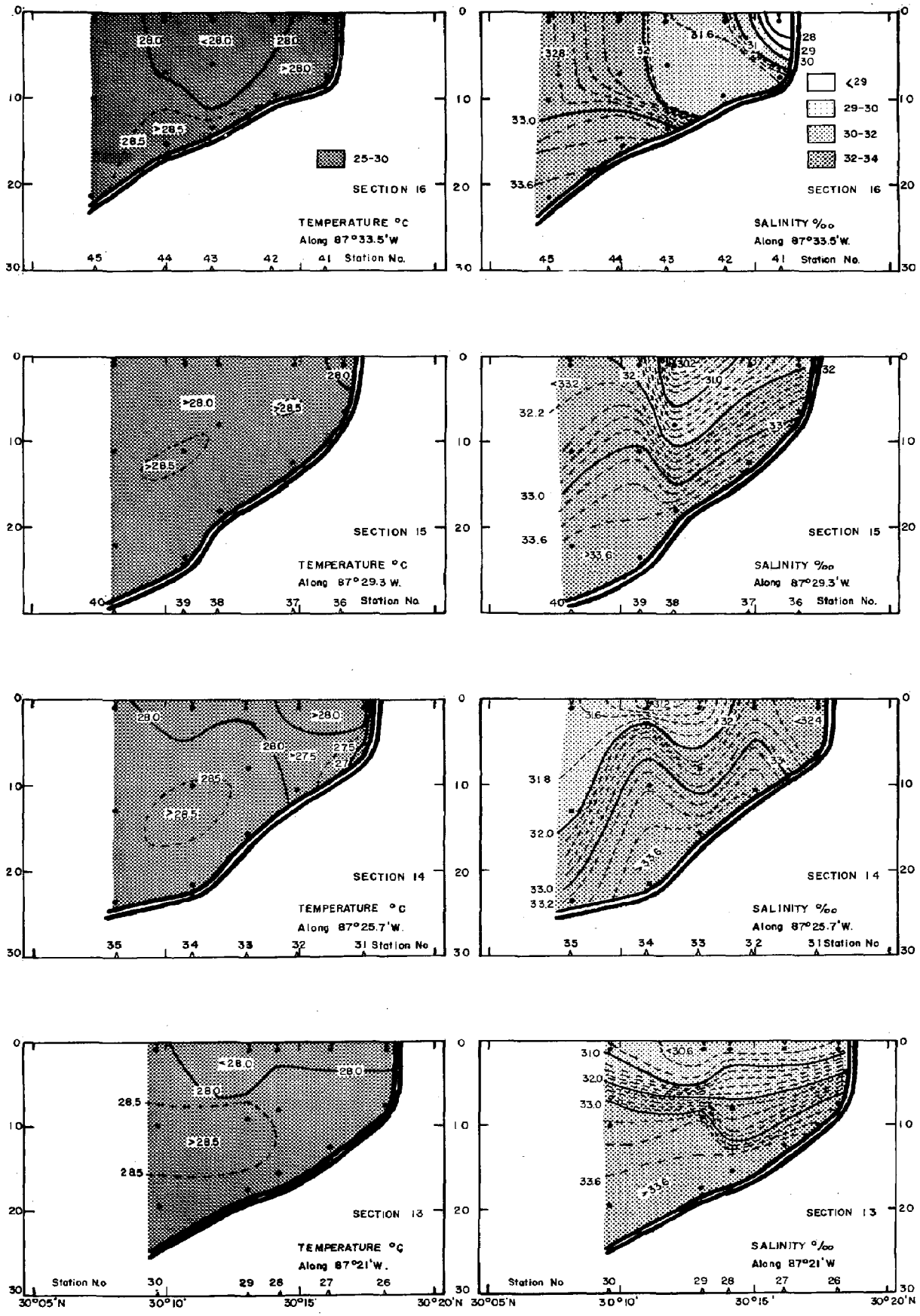


FIGURE 126 VERTICAL DISTRIBUTION - TEMPERATURE AND SALINITY - ESCAROSA I - SEPTEMBER 14 - 16, 1971

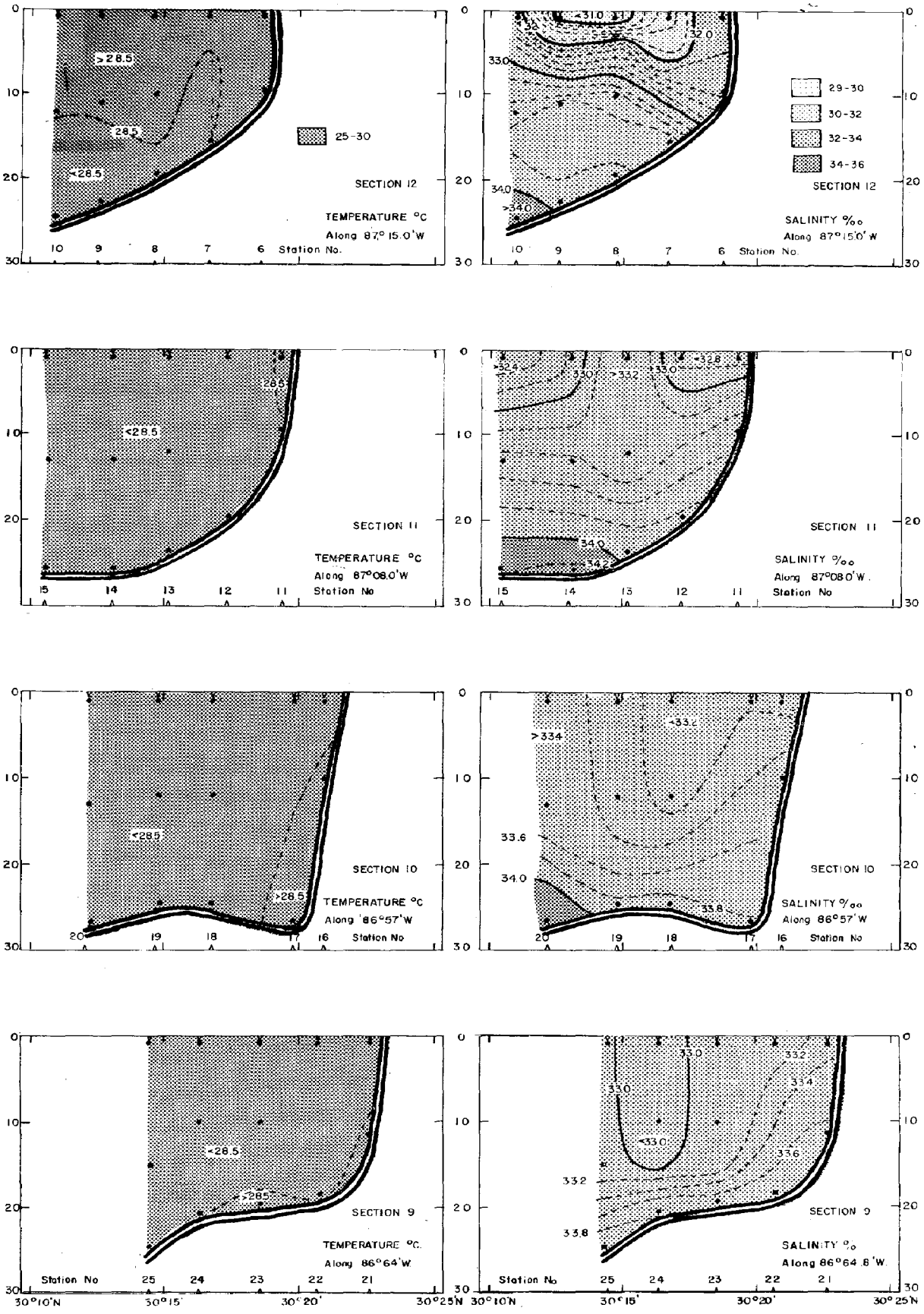


FIGURE 127 VERTICAL DISTRIBUTION - TEMPERATURE AND SALINITY - ESCAROSA I SEPTEMBER 14-16, 1971

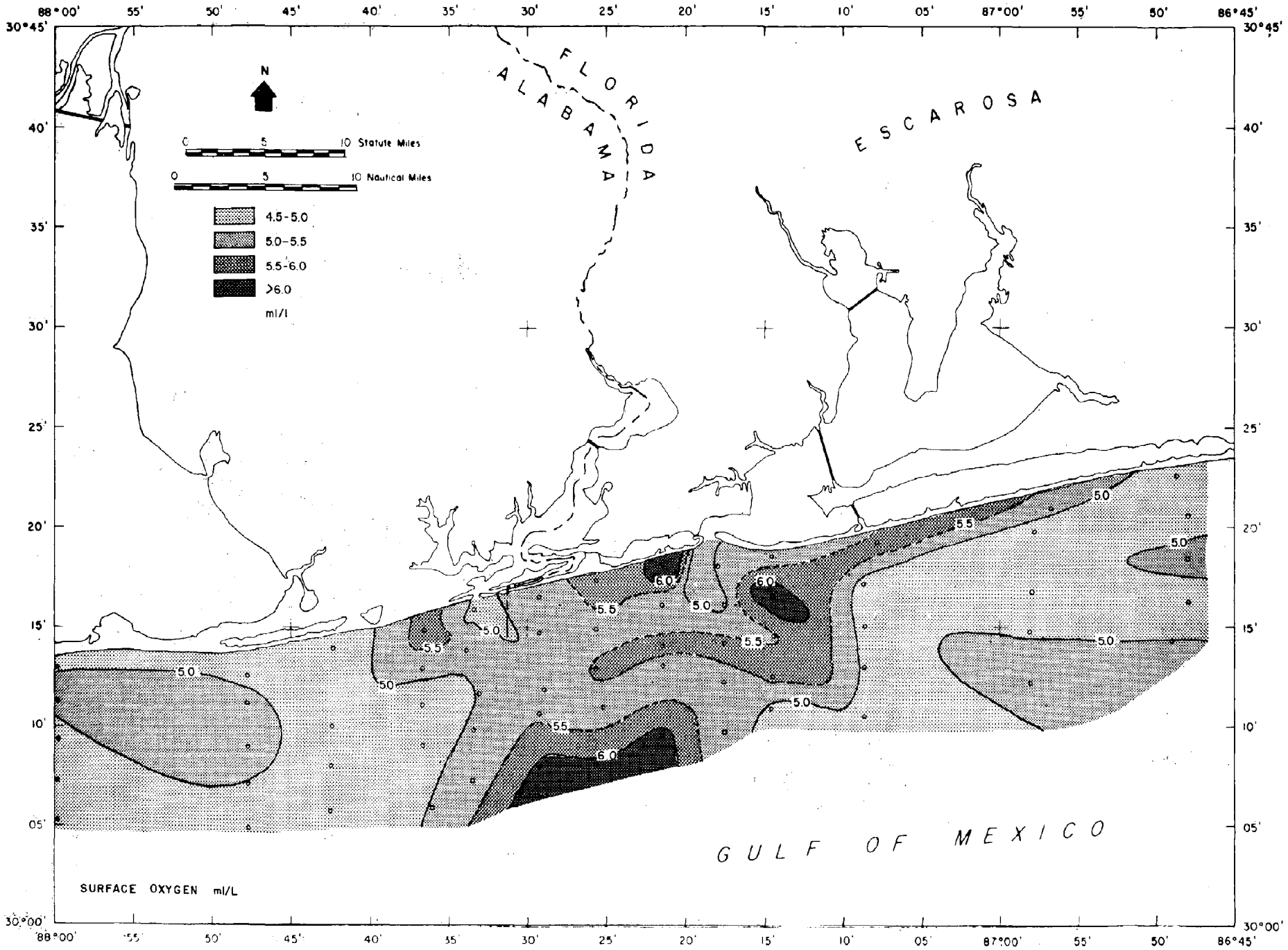


Figure 128 Surface Oxygen Distribution - September 14-16, 1971

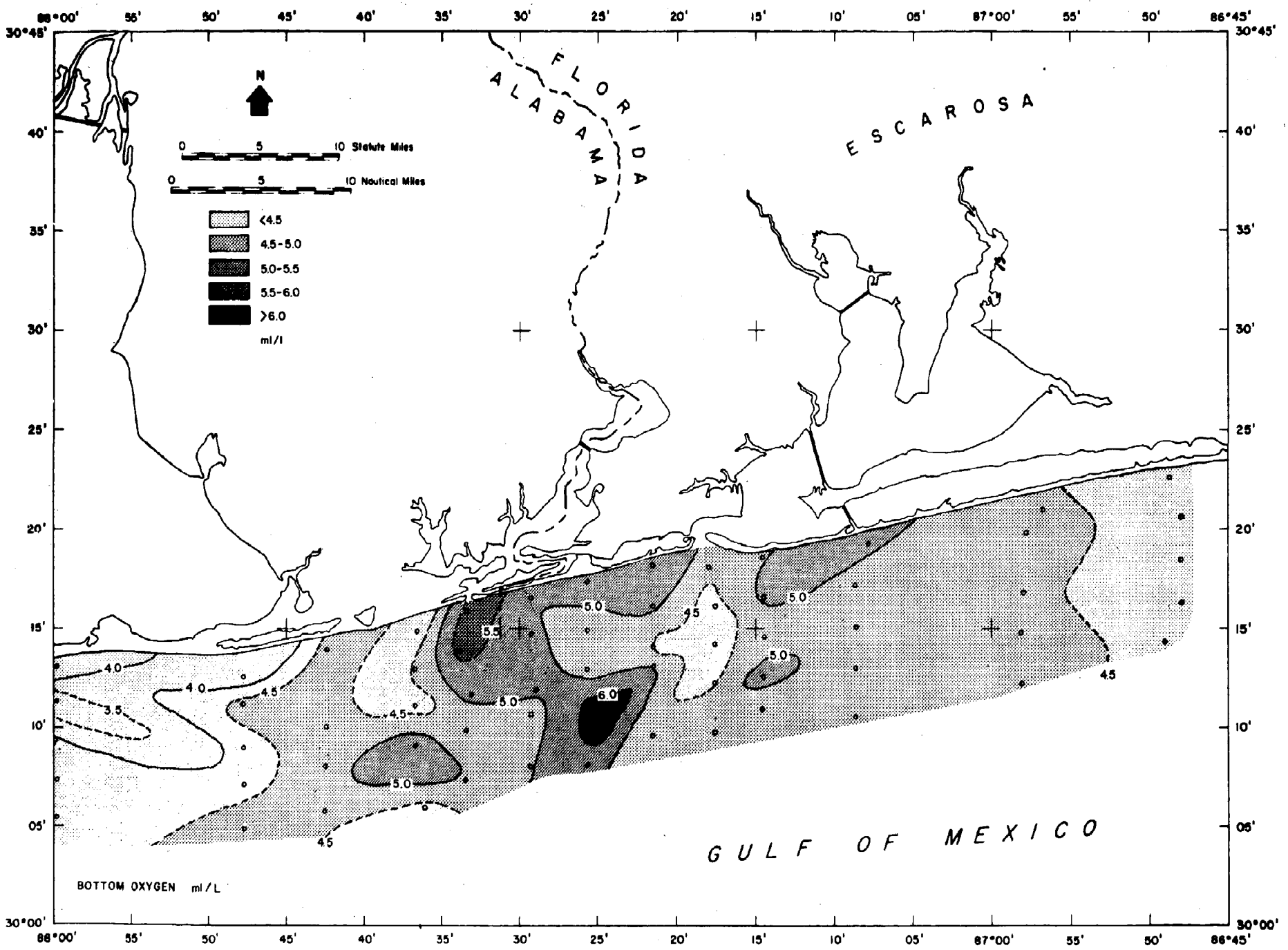


Figure 129 Bottom Oxygen Distribution - September 14-16, 1971

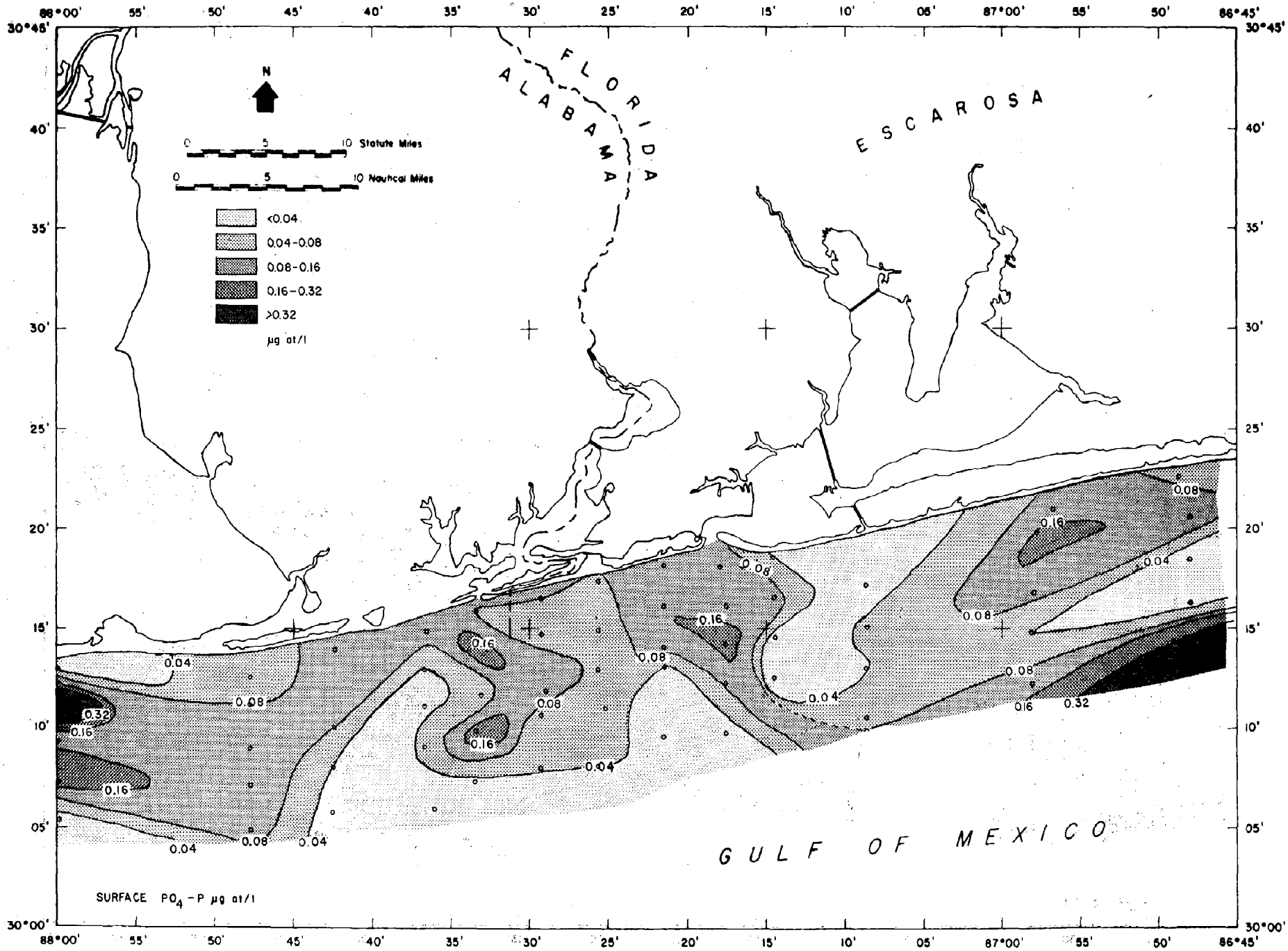


Figure 130 Surface Inorganic Phosphorus – Phosphate Distribution – September 14-16, 1971

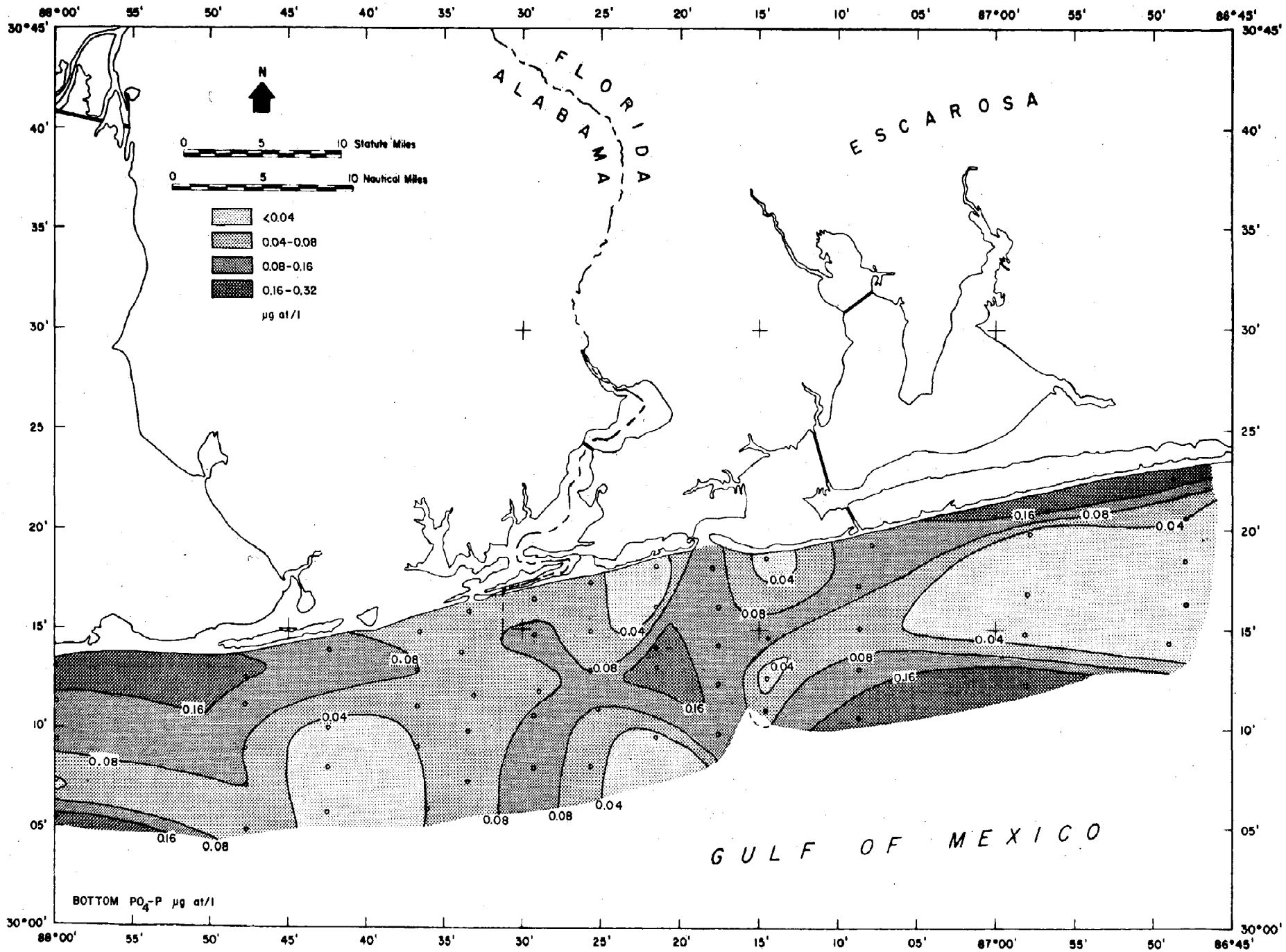


Figure 81 Bottom Inorganic Phosphorus - Phosphate Distribution - September 14-16, 1971

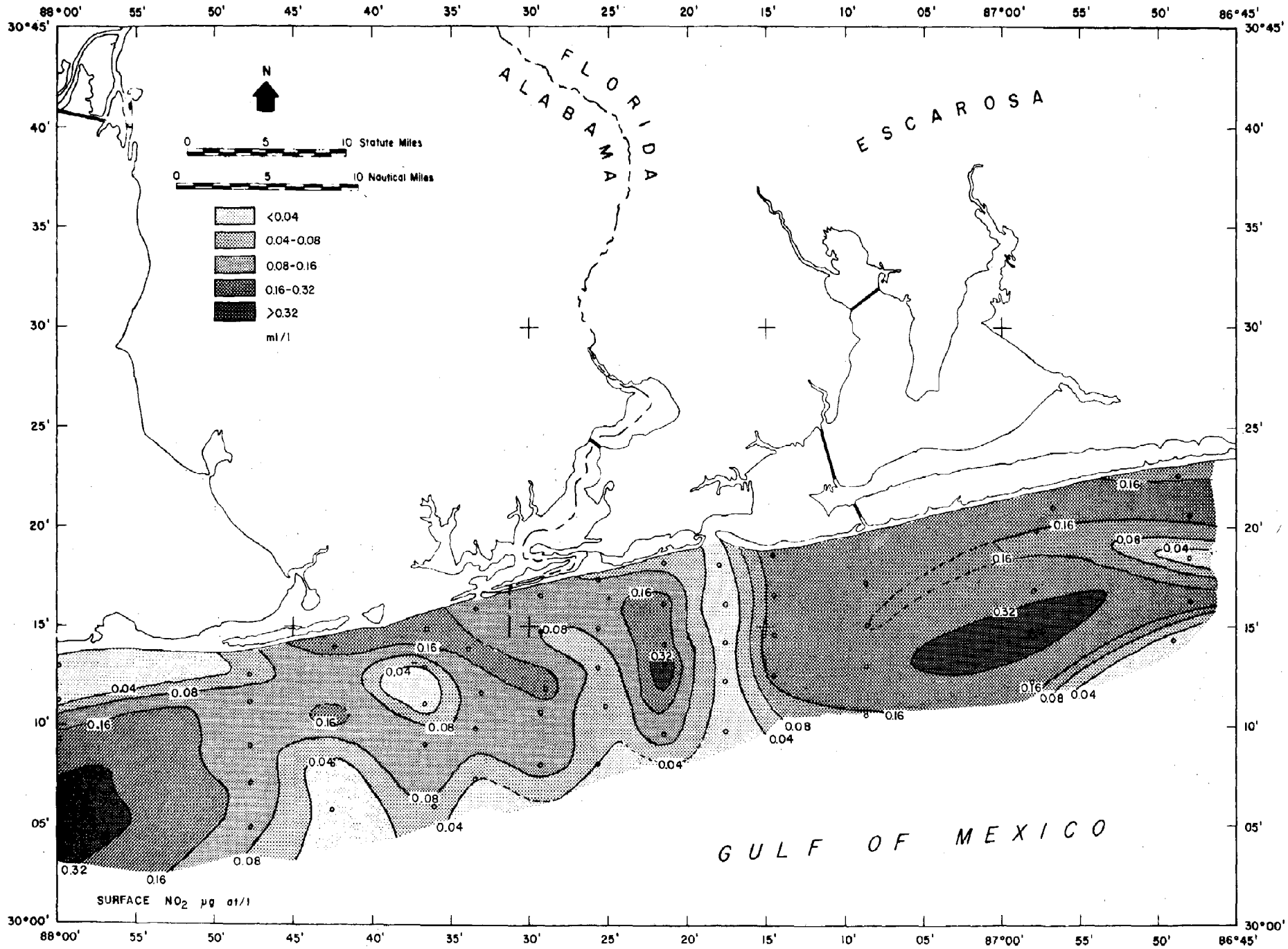


Figure 132 Surface Nitrite-Nitrogen Distribution - September 14-16, 1971

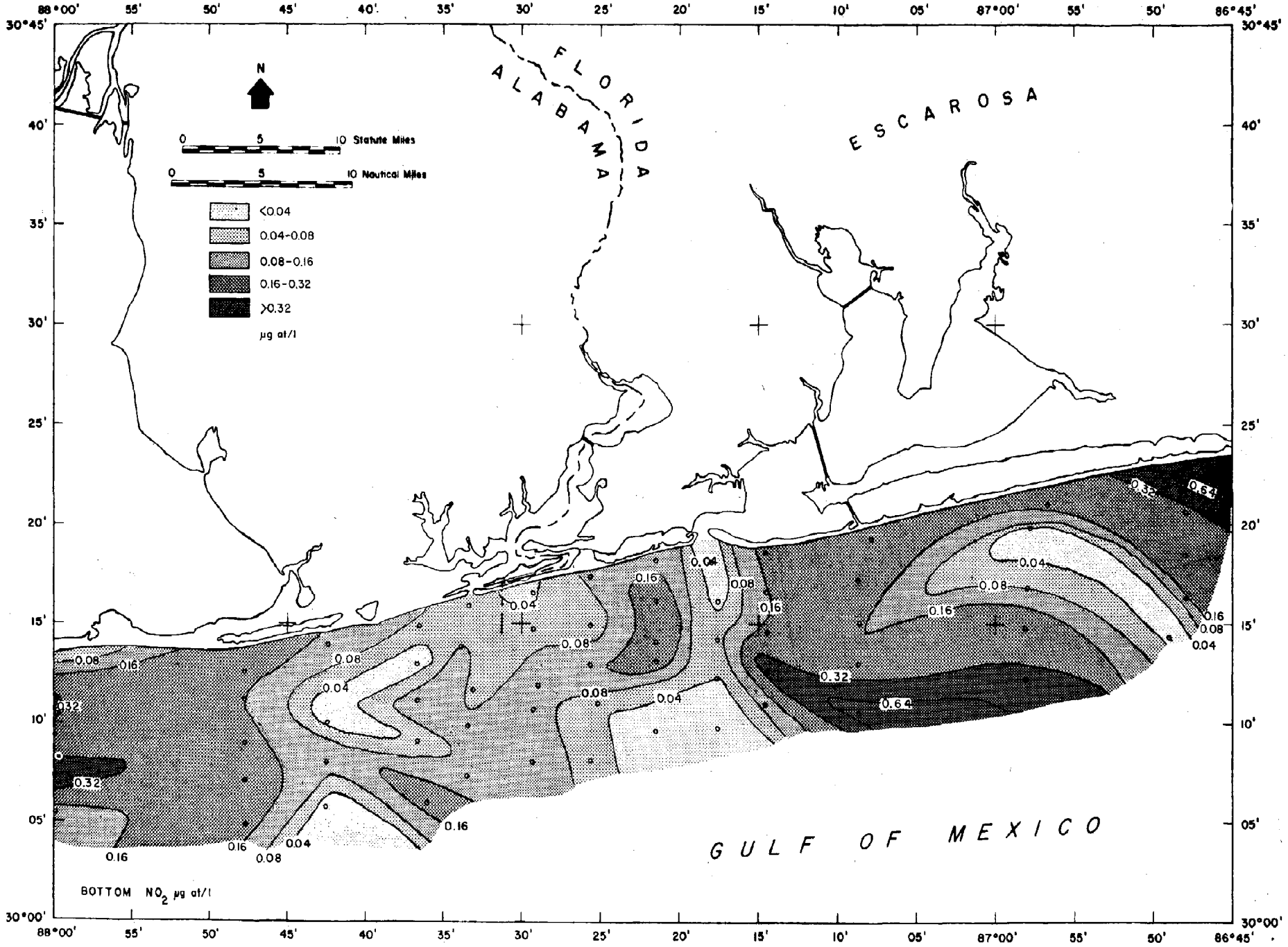


Figure 133 Bottom Nitrite - Nitrogen Distribution - September 14-16, 1971

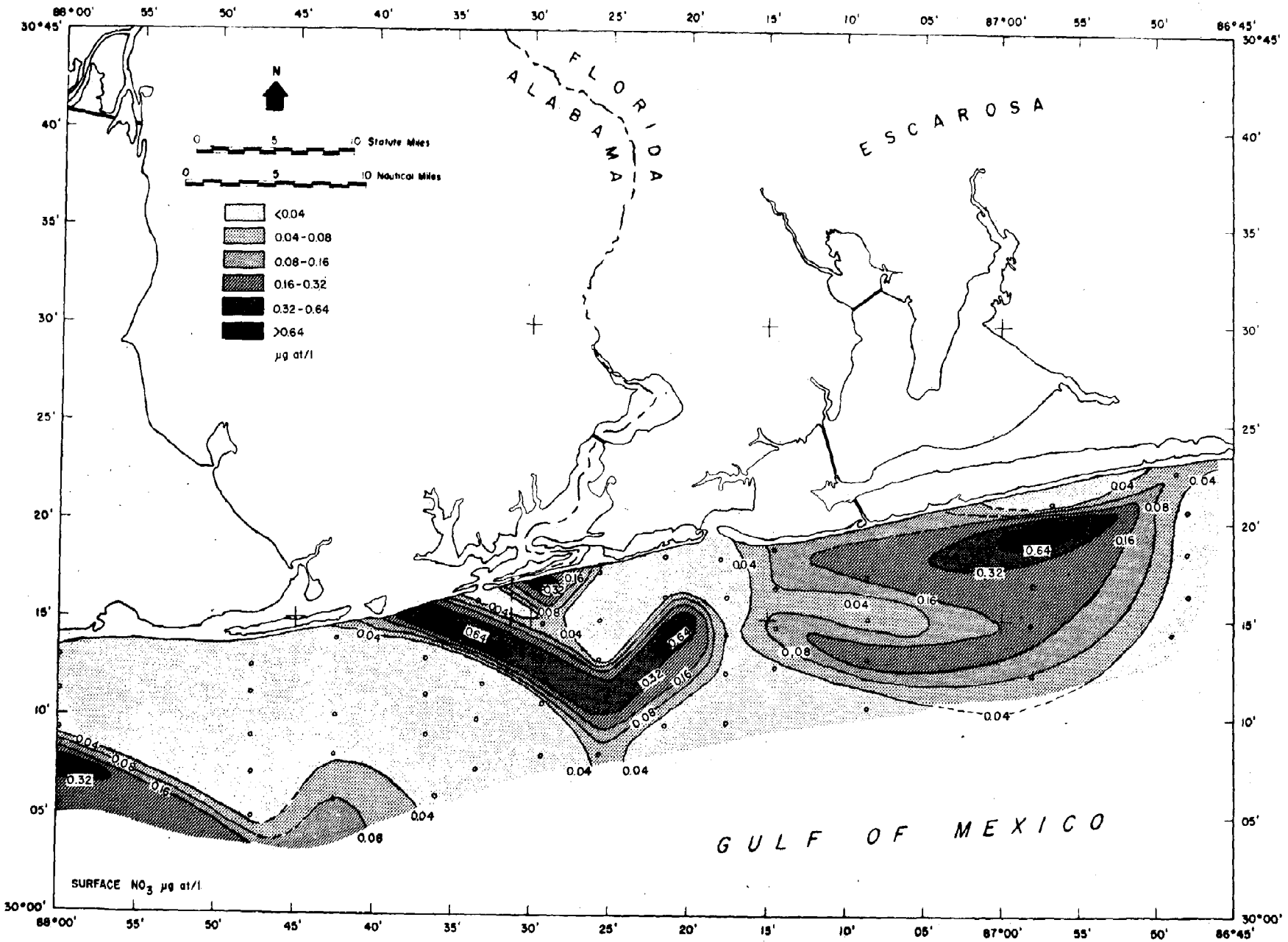


Figure 134 Surface Nitrate-Nitrogen Distribution - September 14-16, 1971

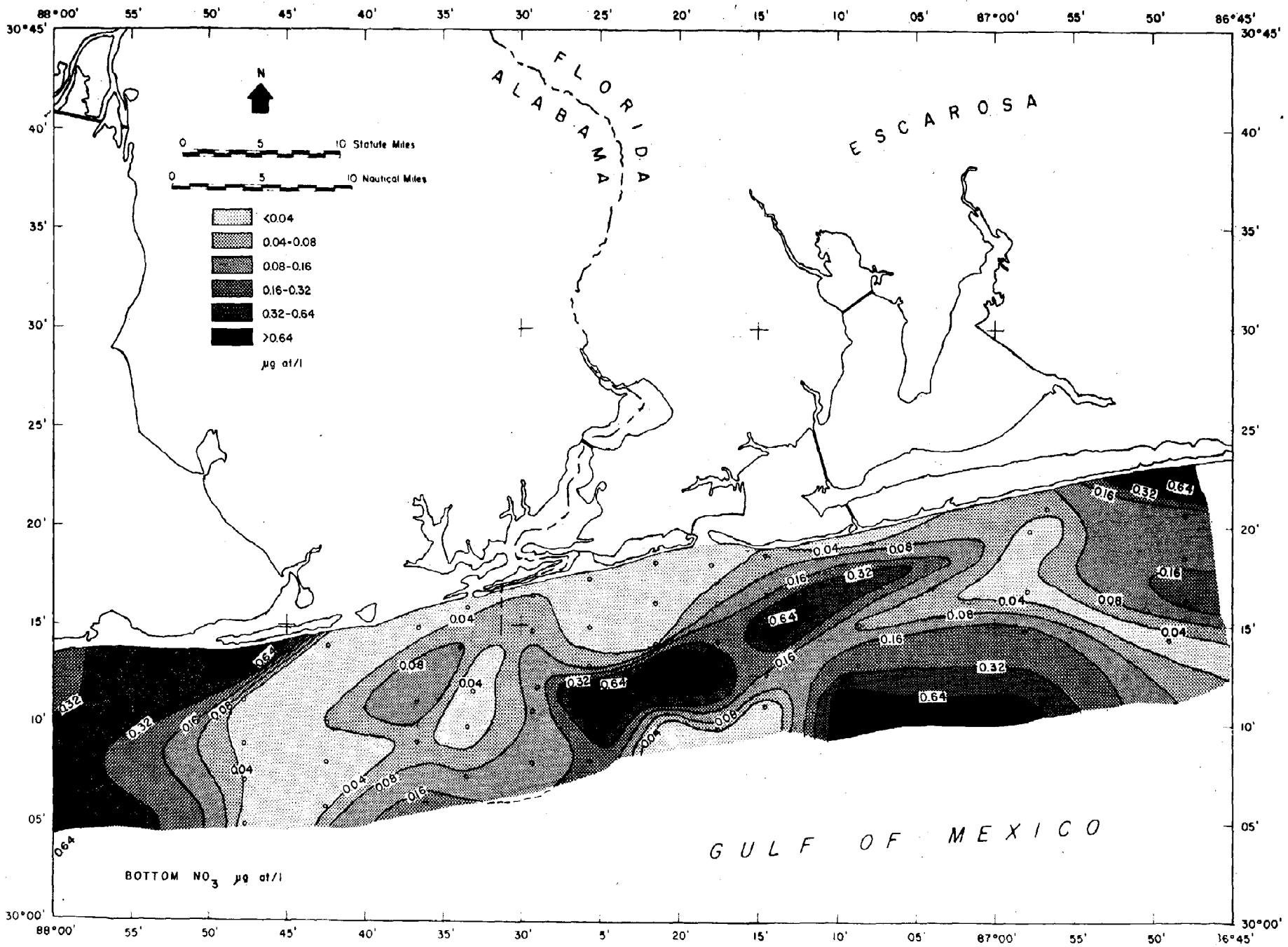


Figure 135 Bottom Nitrate-Nitrogen Distribution - September 14-16, 1971

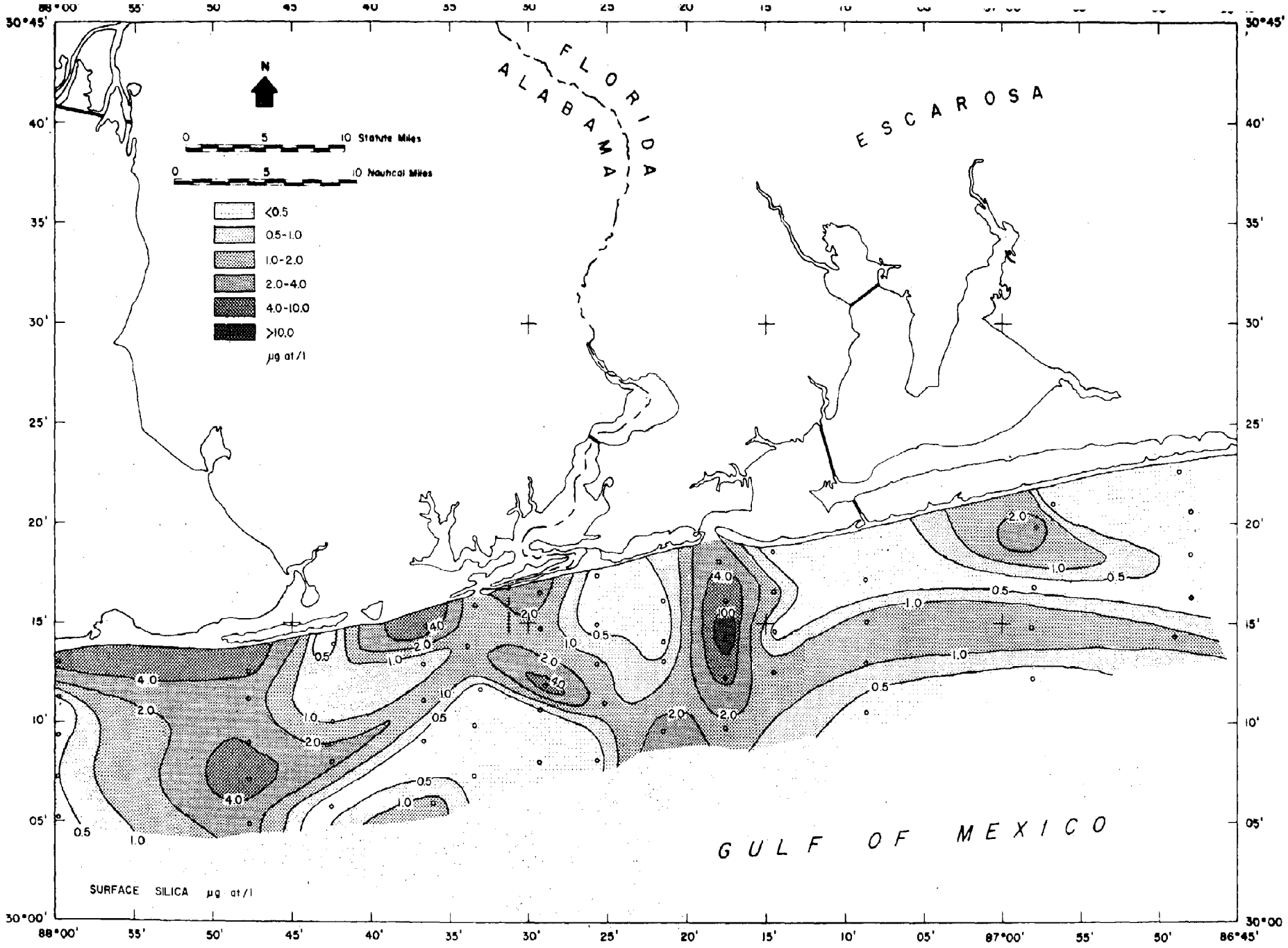


Figure 136 Surface Silica Distribution - September 14-16, 1971

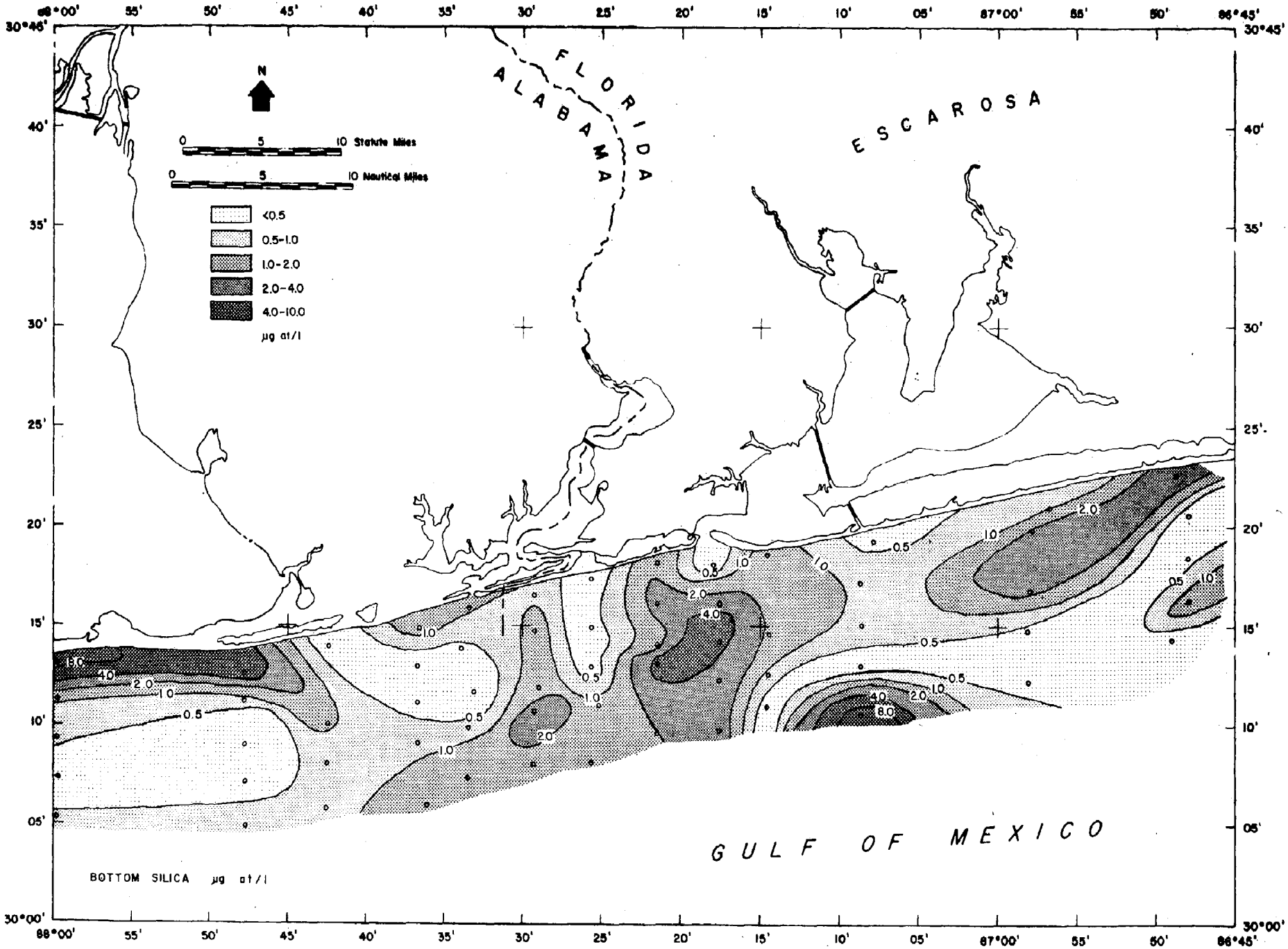


Figure 137 Bottom Silica Distribution - September 14-16, 1971

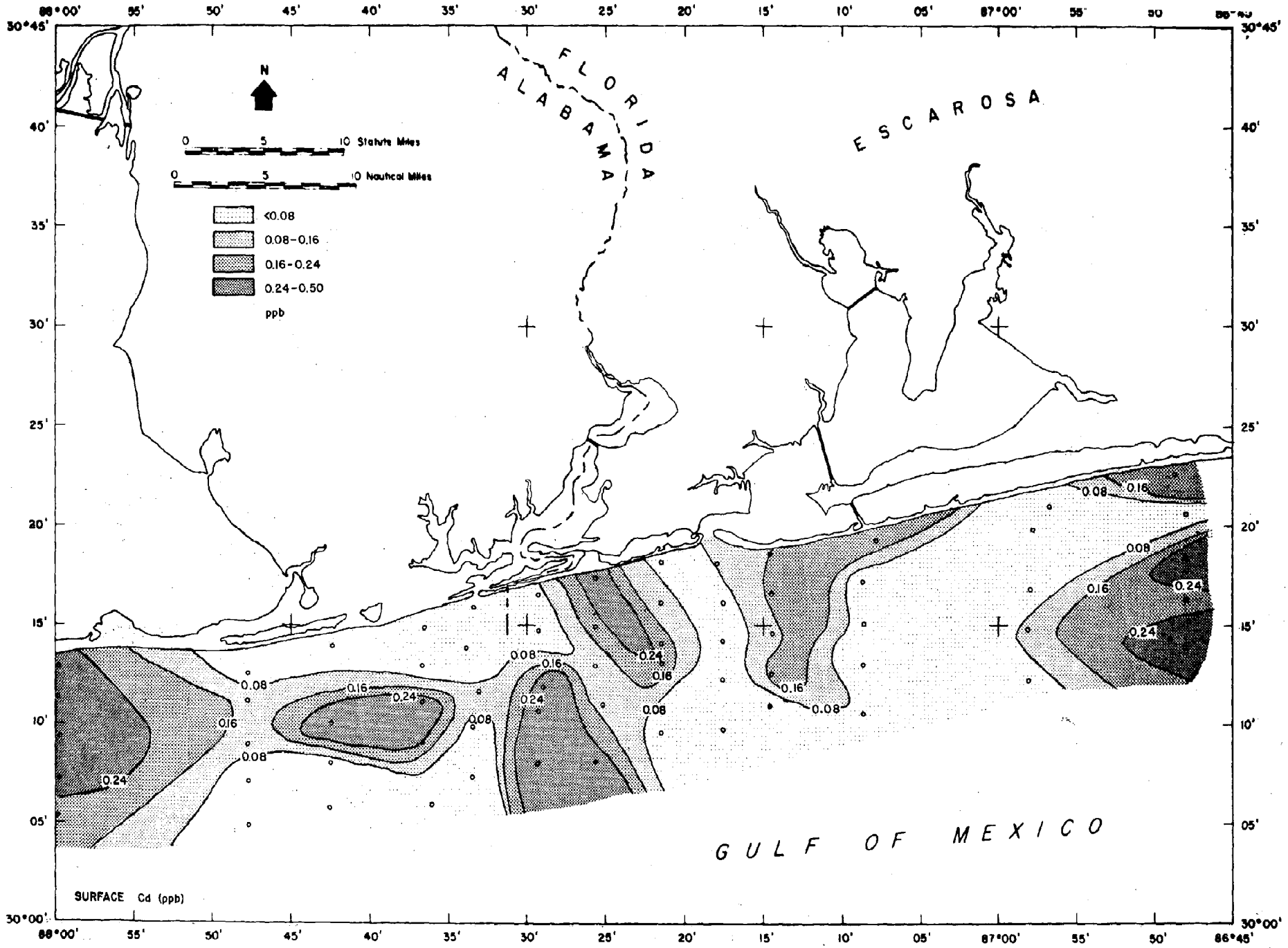


Figure 138 Surface Cadmium Distribution - September 14-16, 1971

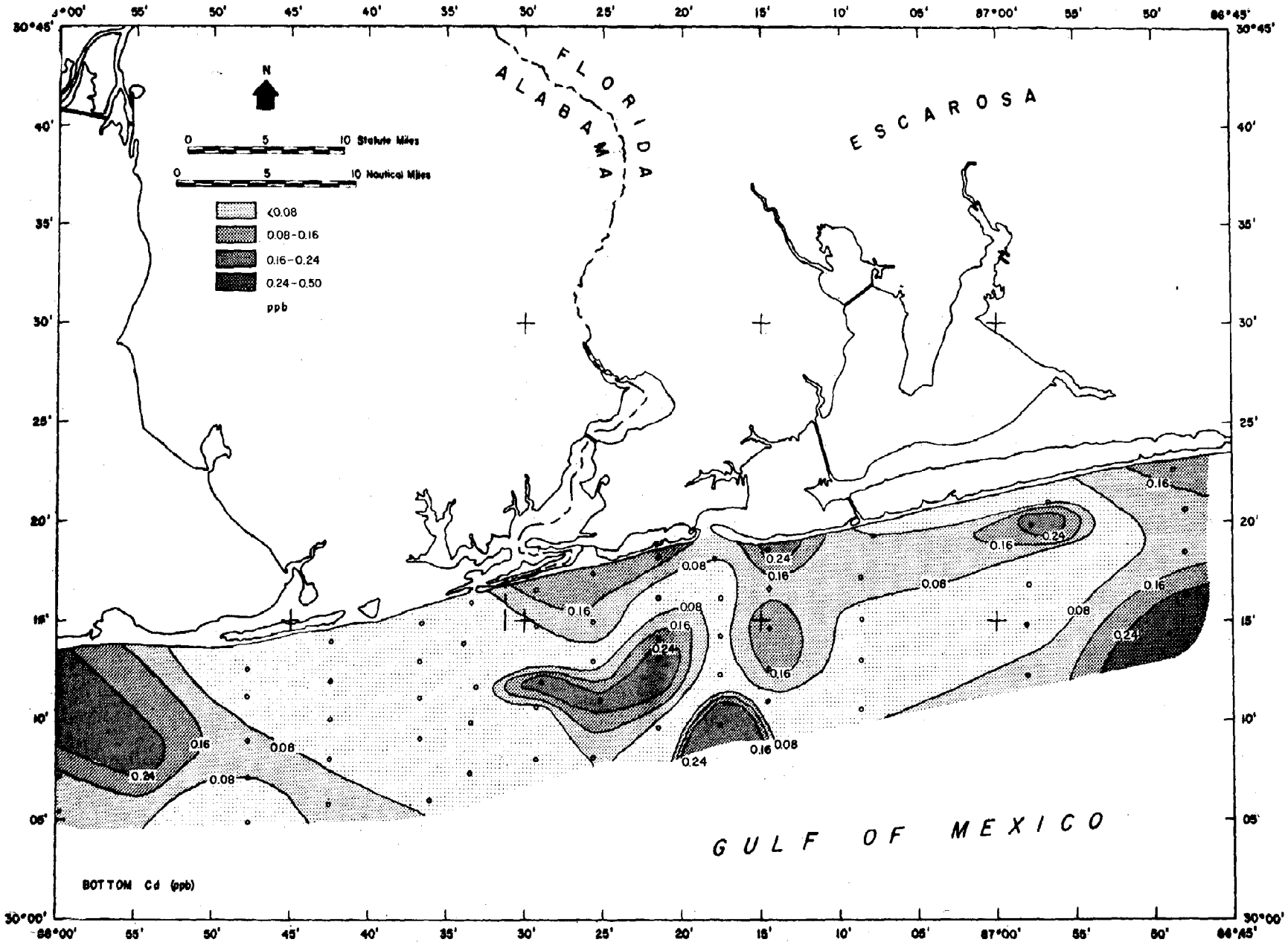


Figure 139 Bottom Cadmium Distribution – September 14-16, 1971

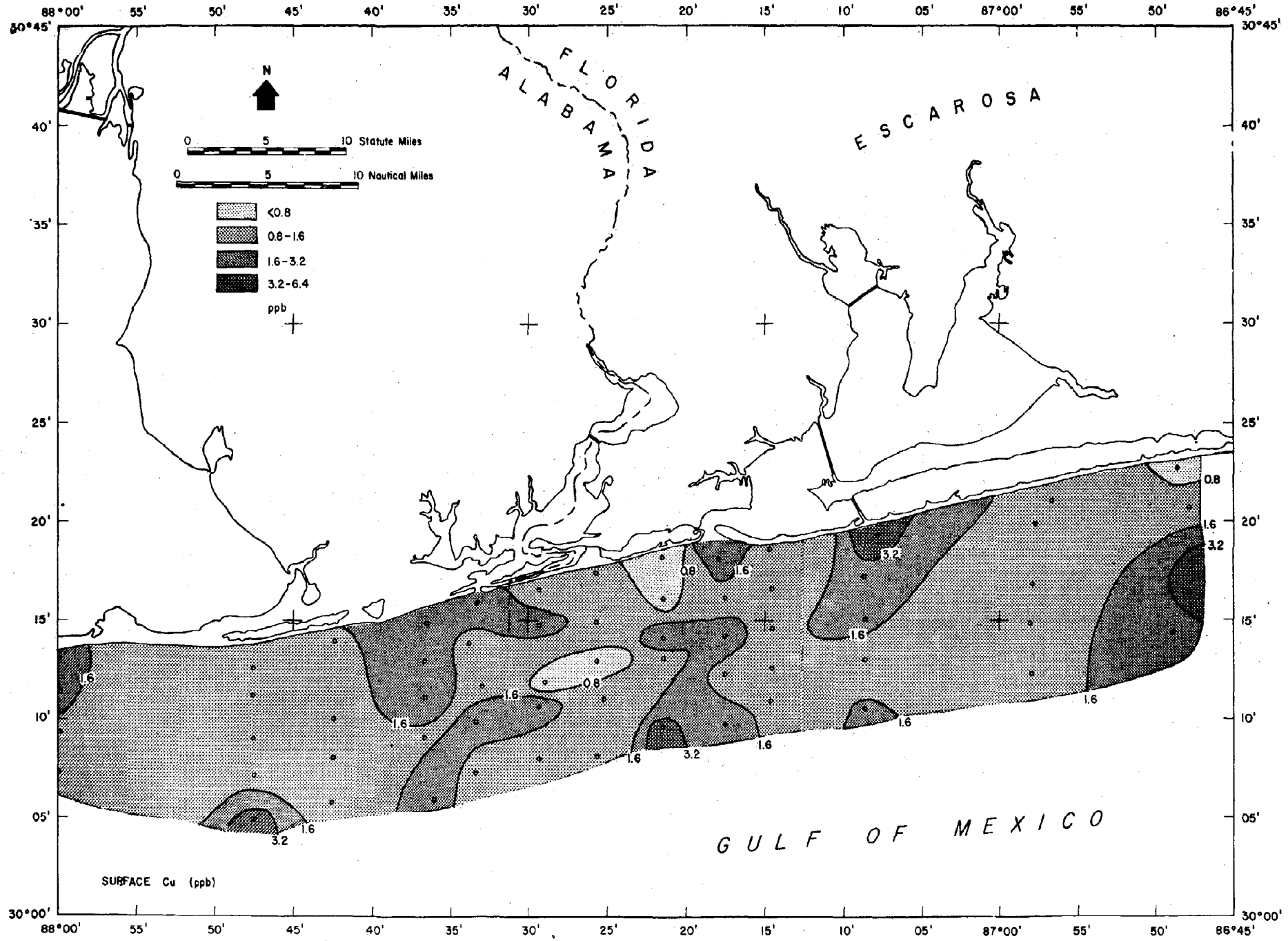


Figure 140 Surface Copper Distribution - September 14-16, 1971

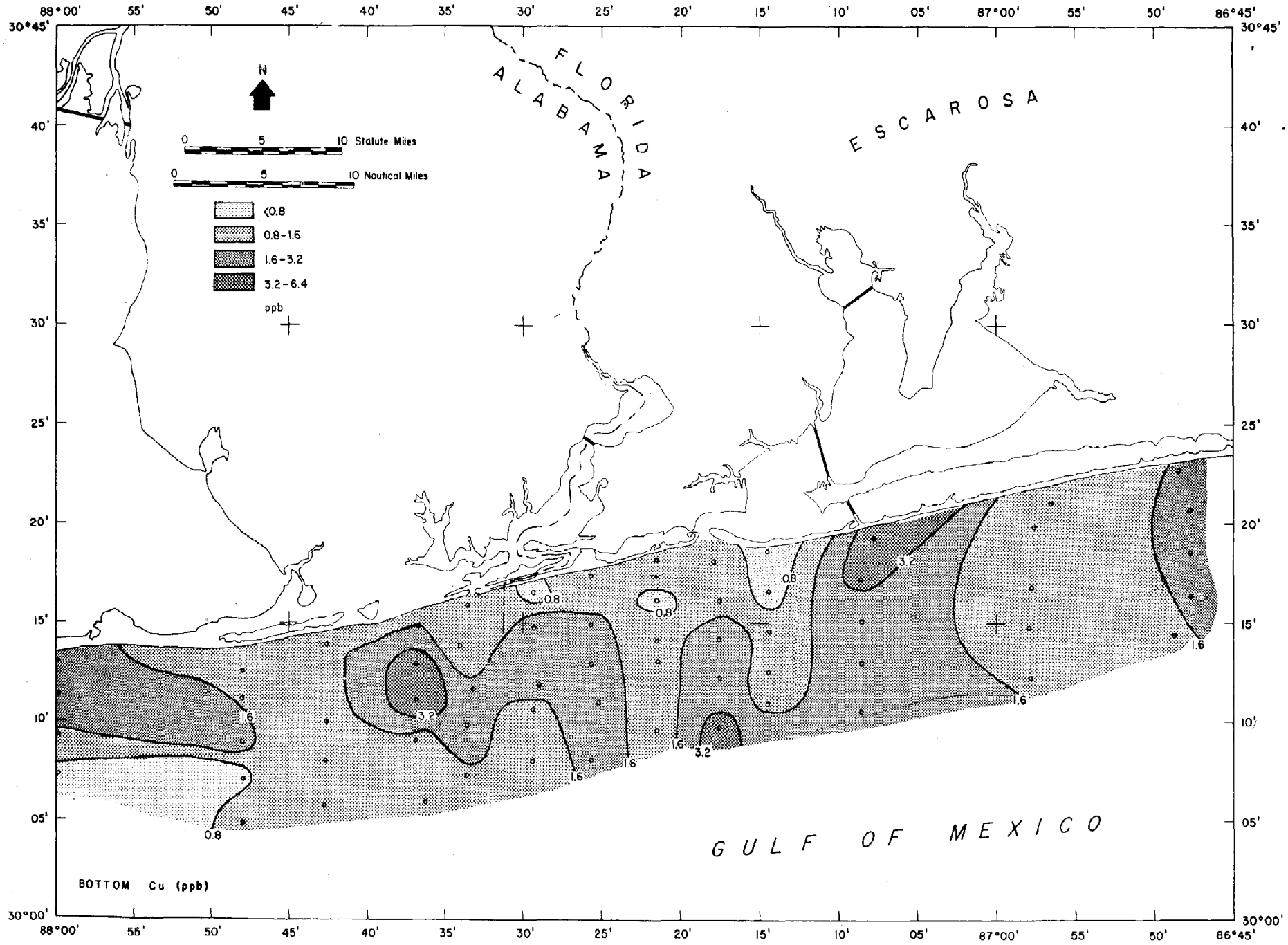


Figure 141 Bottom Copper Distribution - September 14-16, 1971

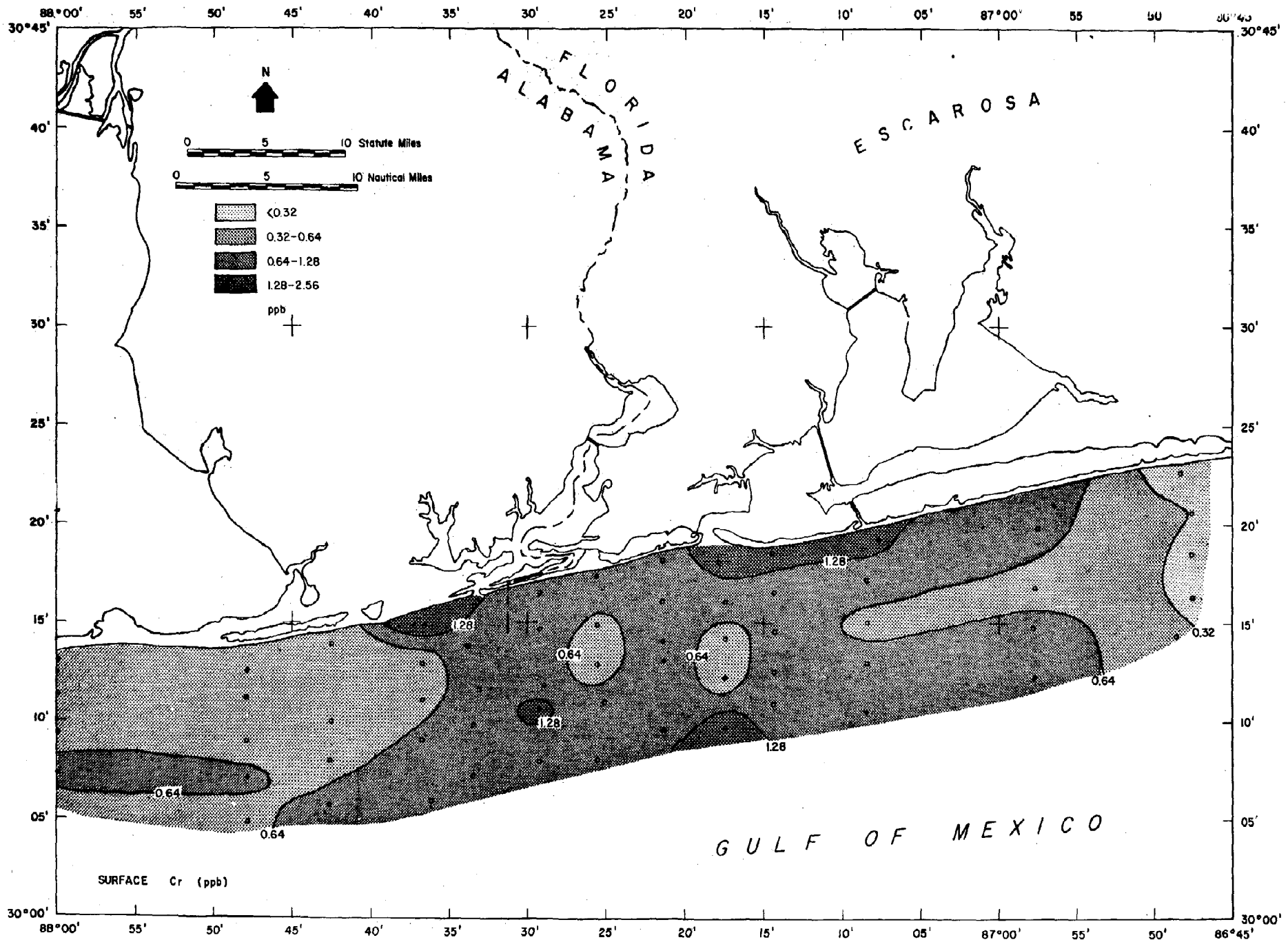


Figure 142 Surface Chromium Distribution - September 14-16, 1971

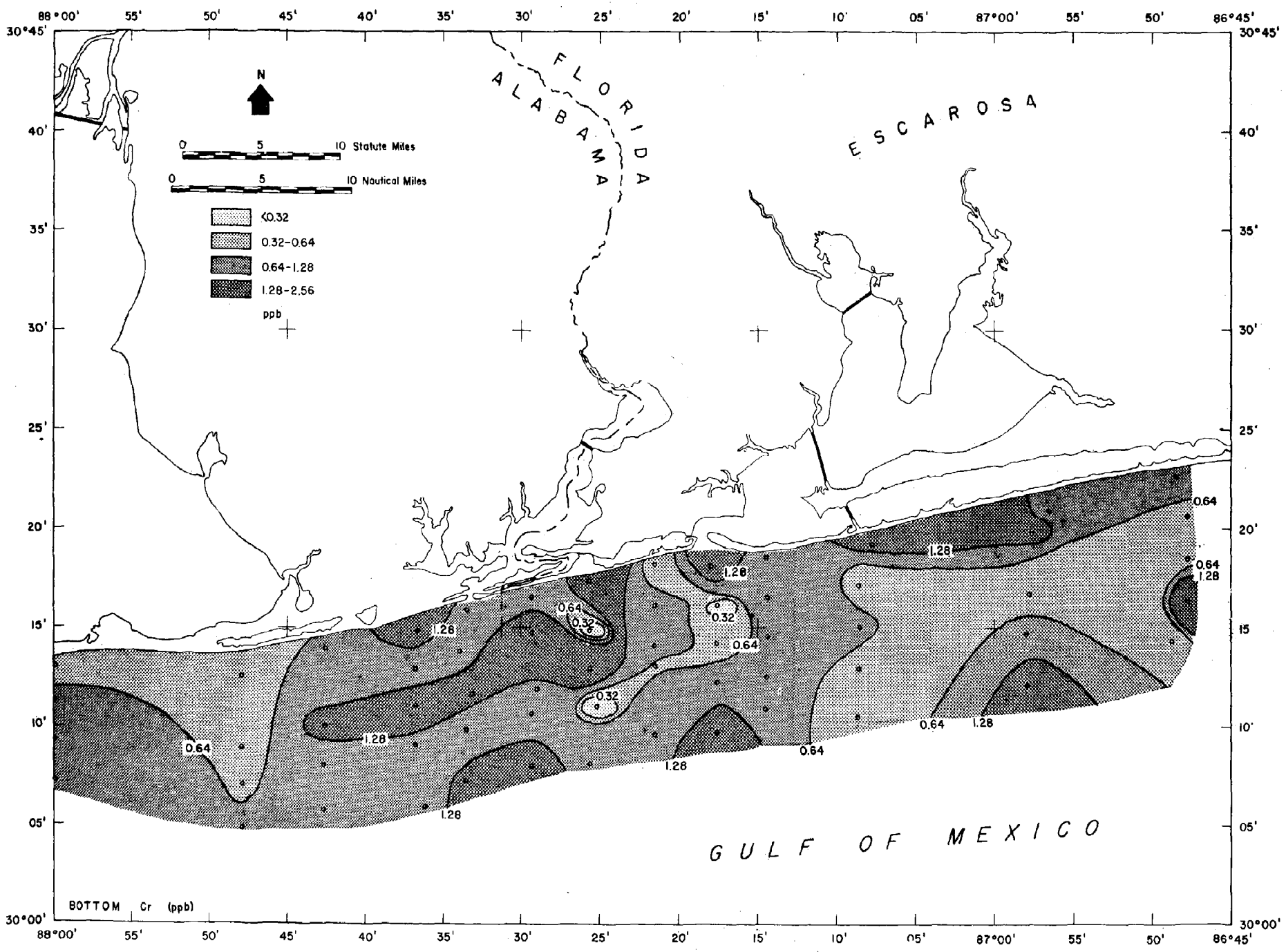


Figure 143 Bottom Chromium Distribution - September 14-16, 1971

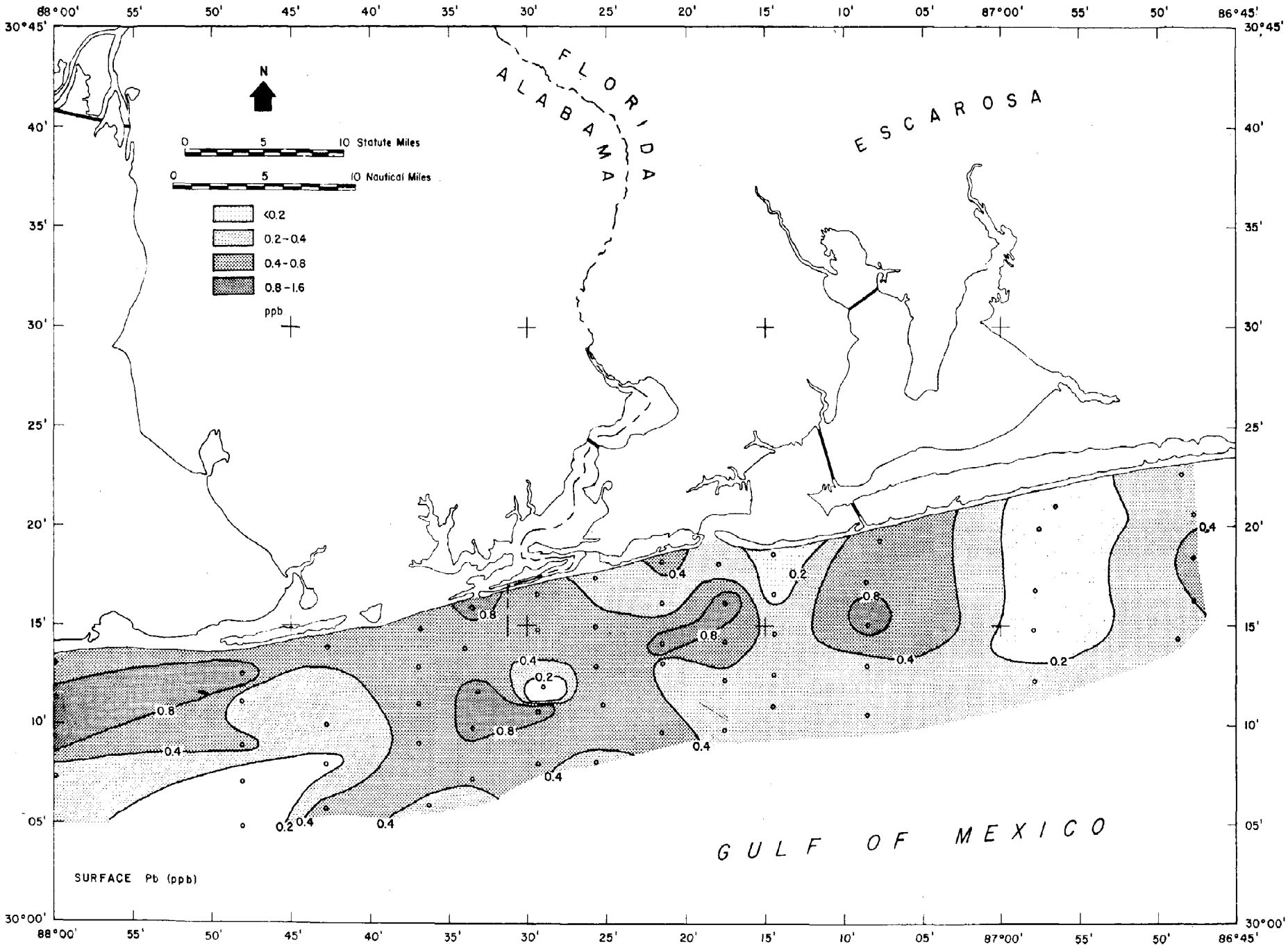


Figure 144 Surface Lead Distribution – September 14-16, 1971

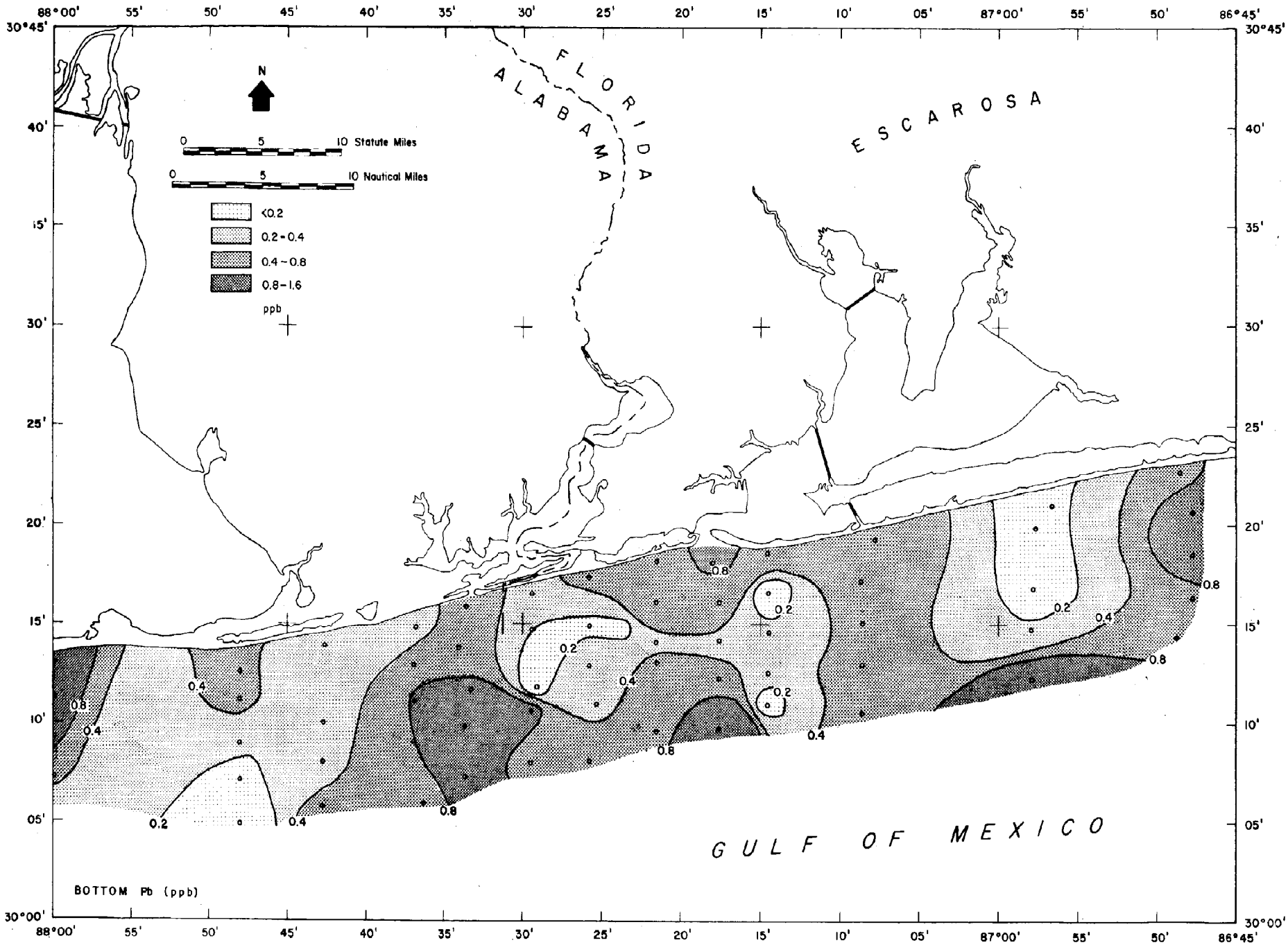


Figure 145 Bottom Lead Distribution – September 14-16, 1971

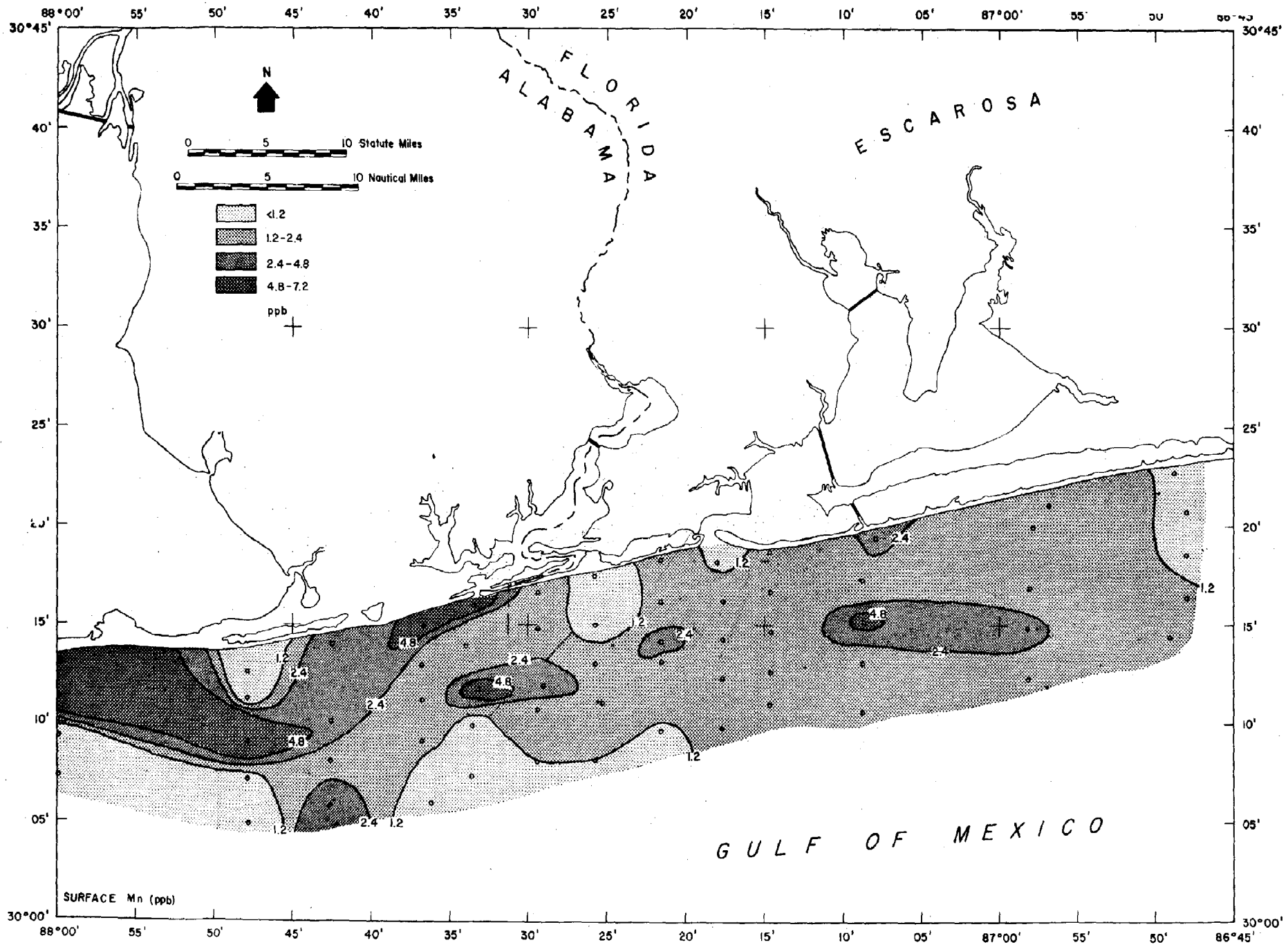


Figure 146 Surface Manganese Distribution – September 14-16, 1971

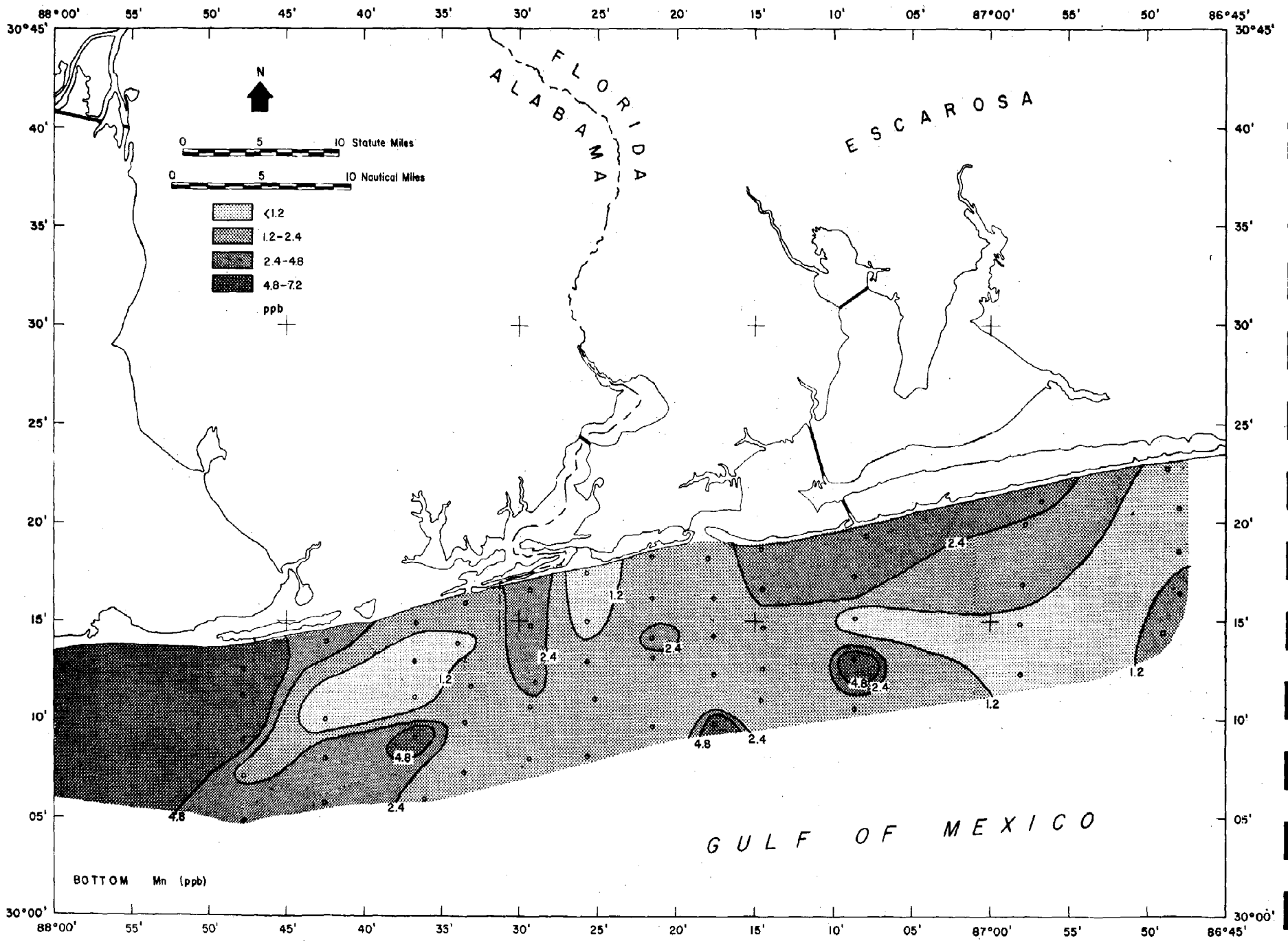


Figure 147 Bottom Manganese Distribution - September 14-16, 1971

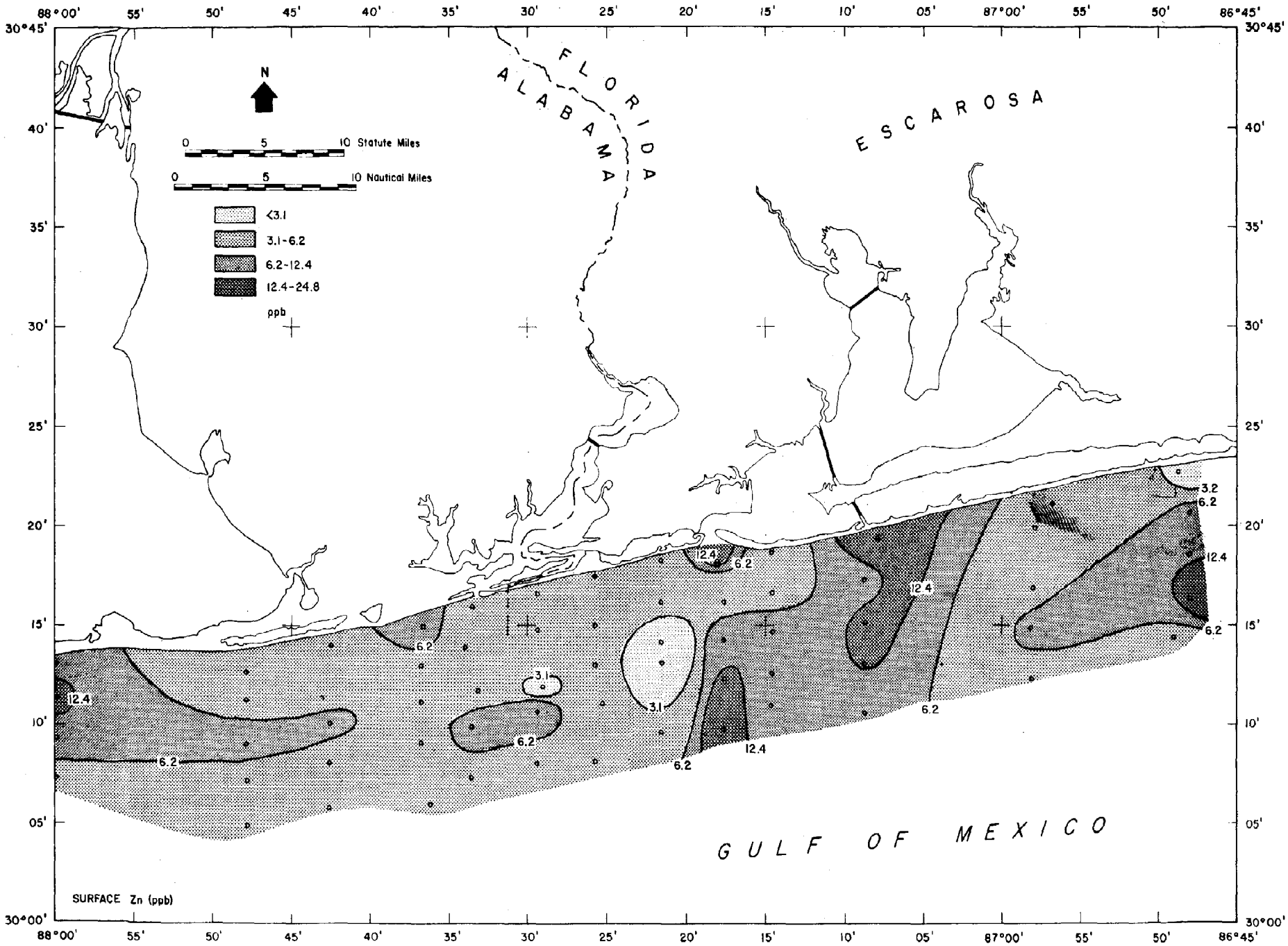


Figure 148 Surface Zinc Distribution - September 14-16, 1971

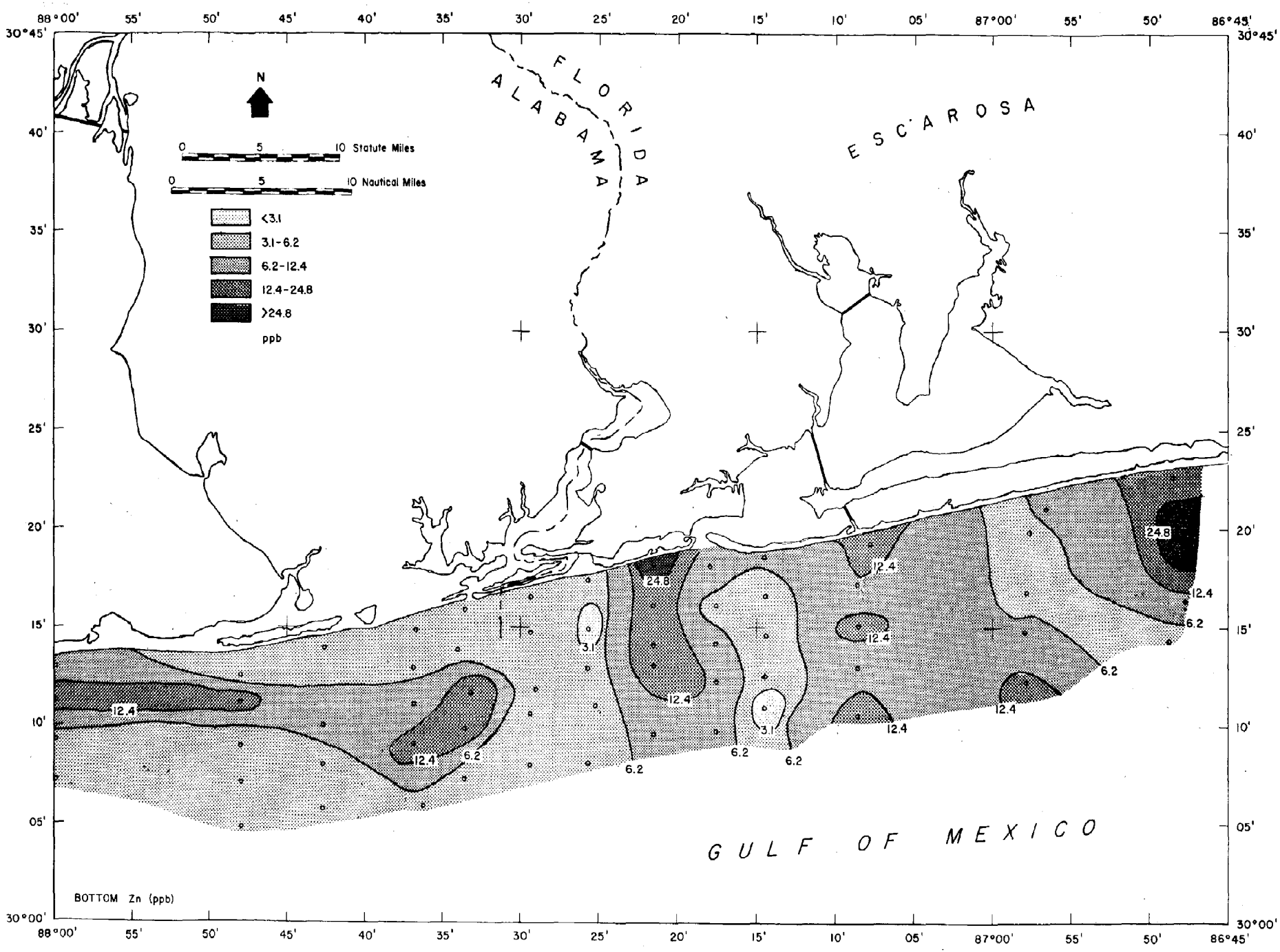


Figure 149 Bottom Zinc Distribution - September 14-16, 1971

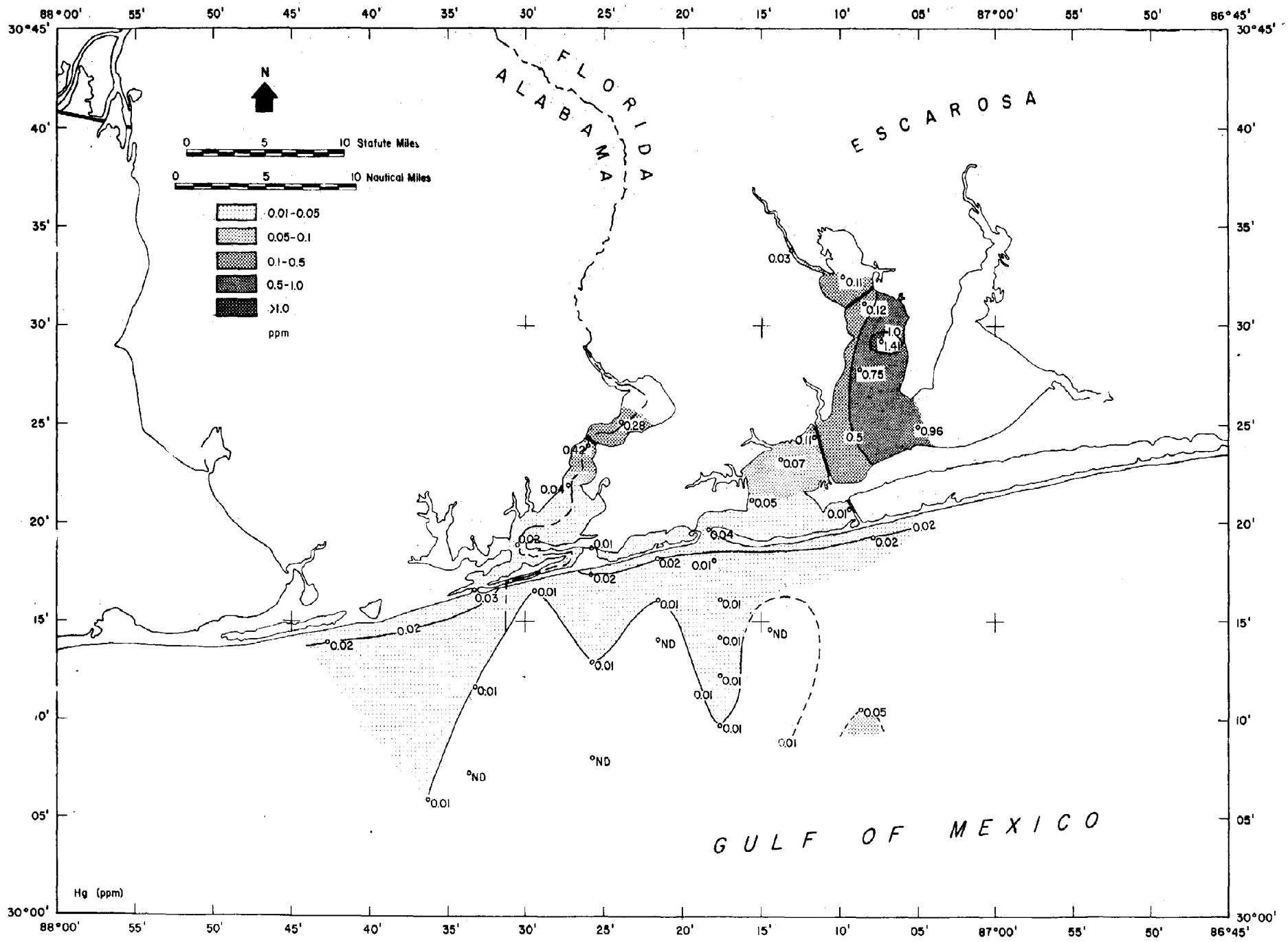


Figure 150 Distribution of Mercury in the Sediments

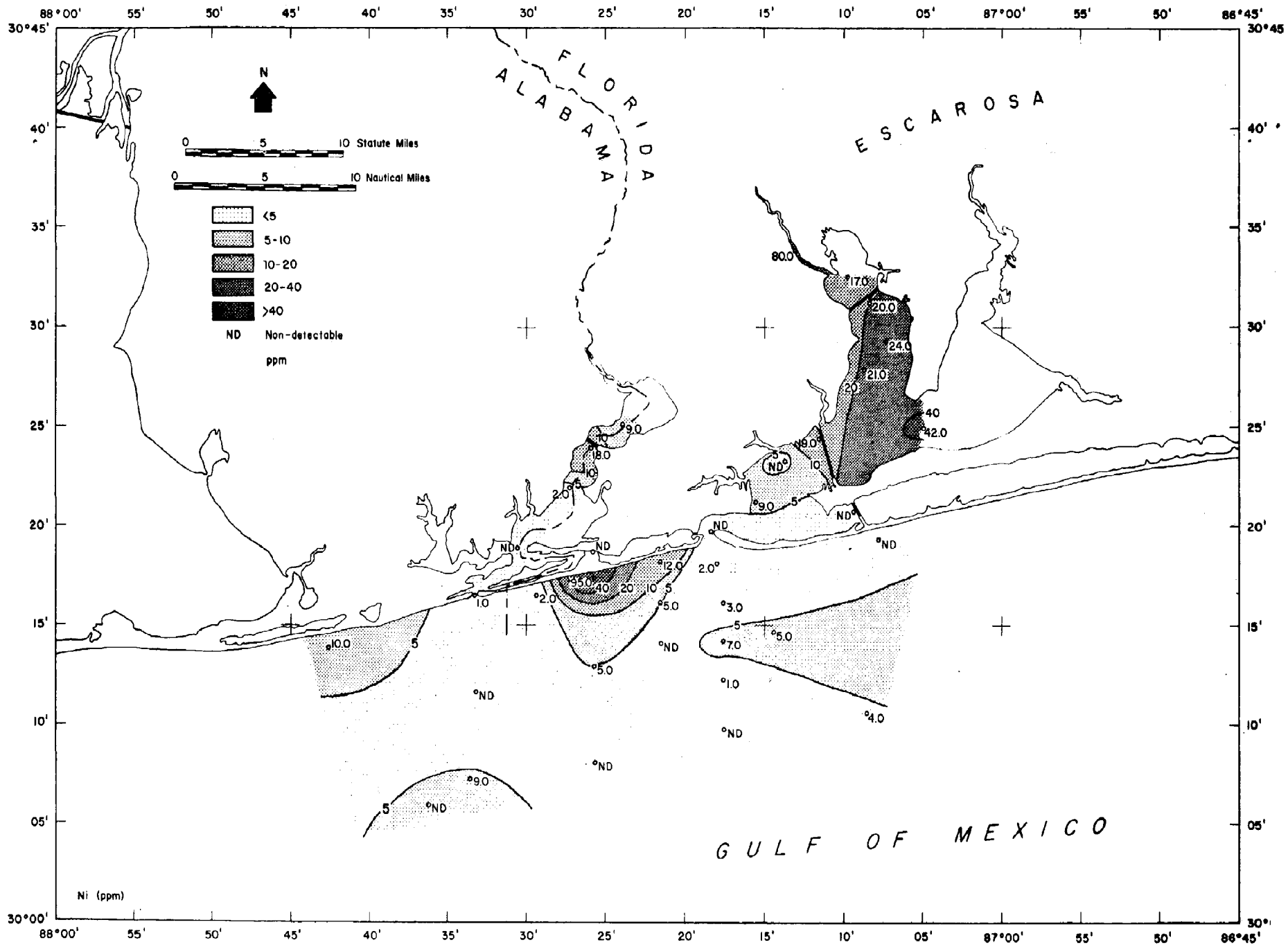


Figure 151 Distribution of Nickel in the Sediments

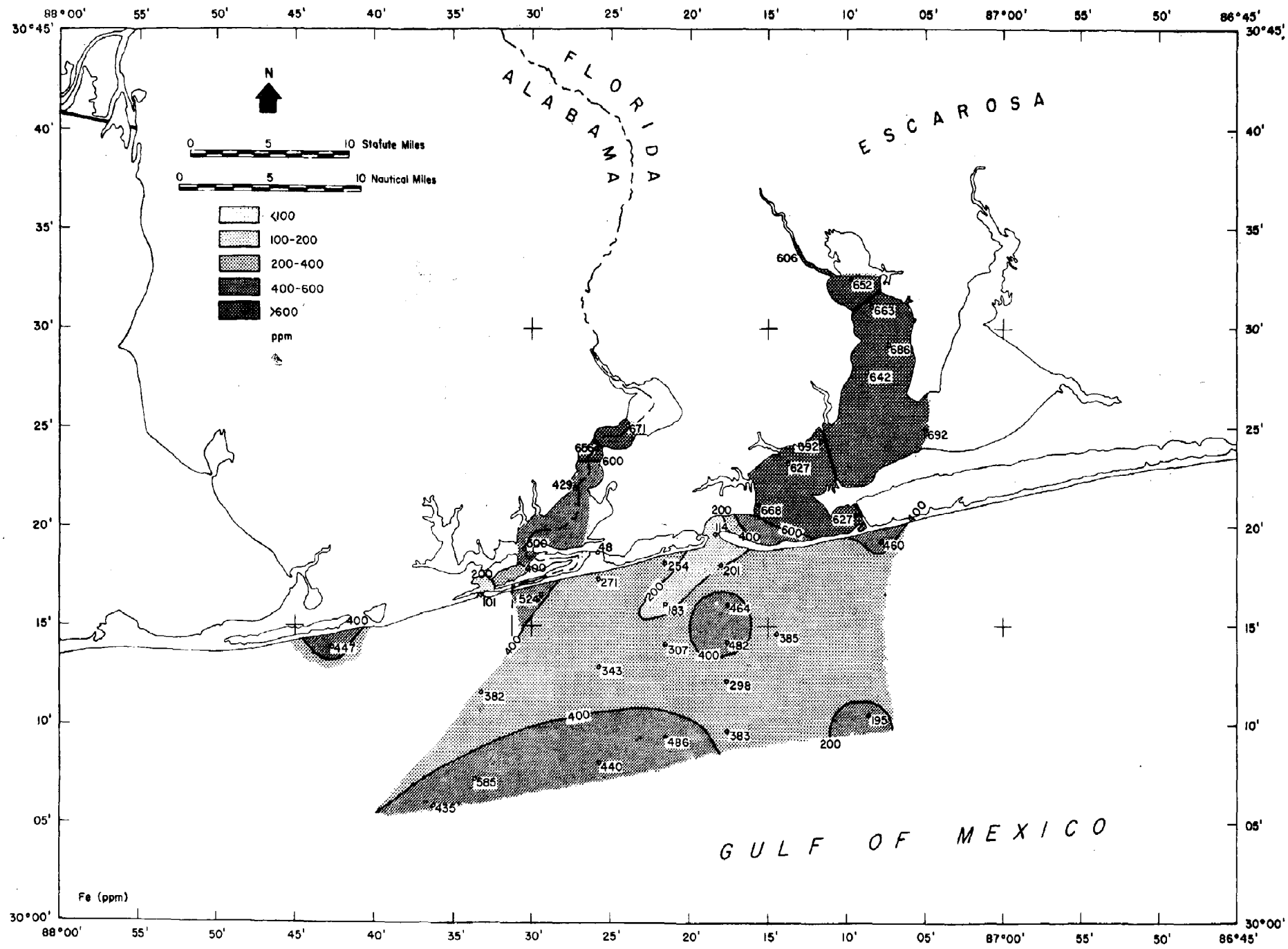


Figure 152 Distribution of Iron in the Sediments

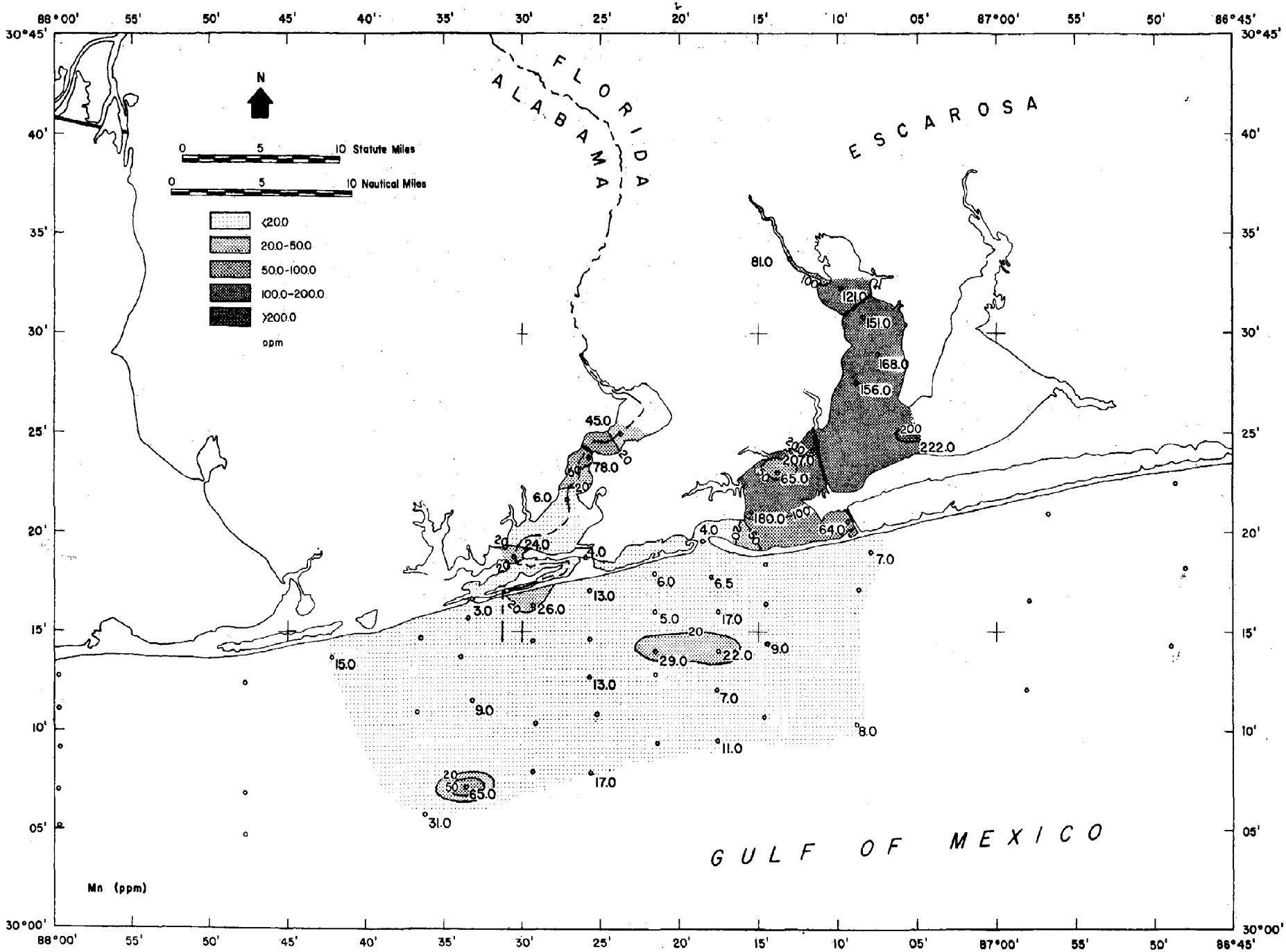


Figure 153 Distribution of Manganese in the Sediments

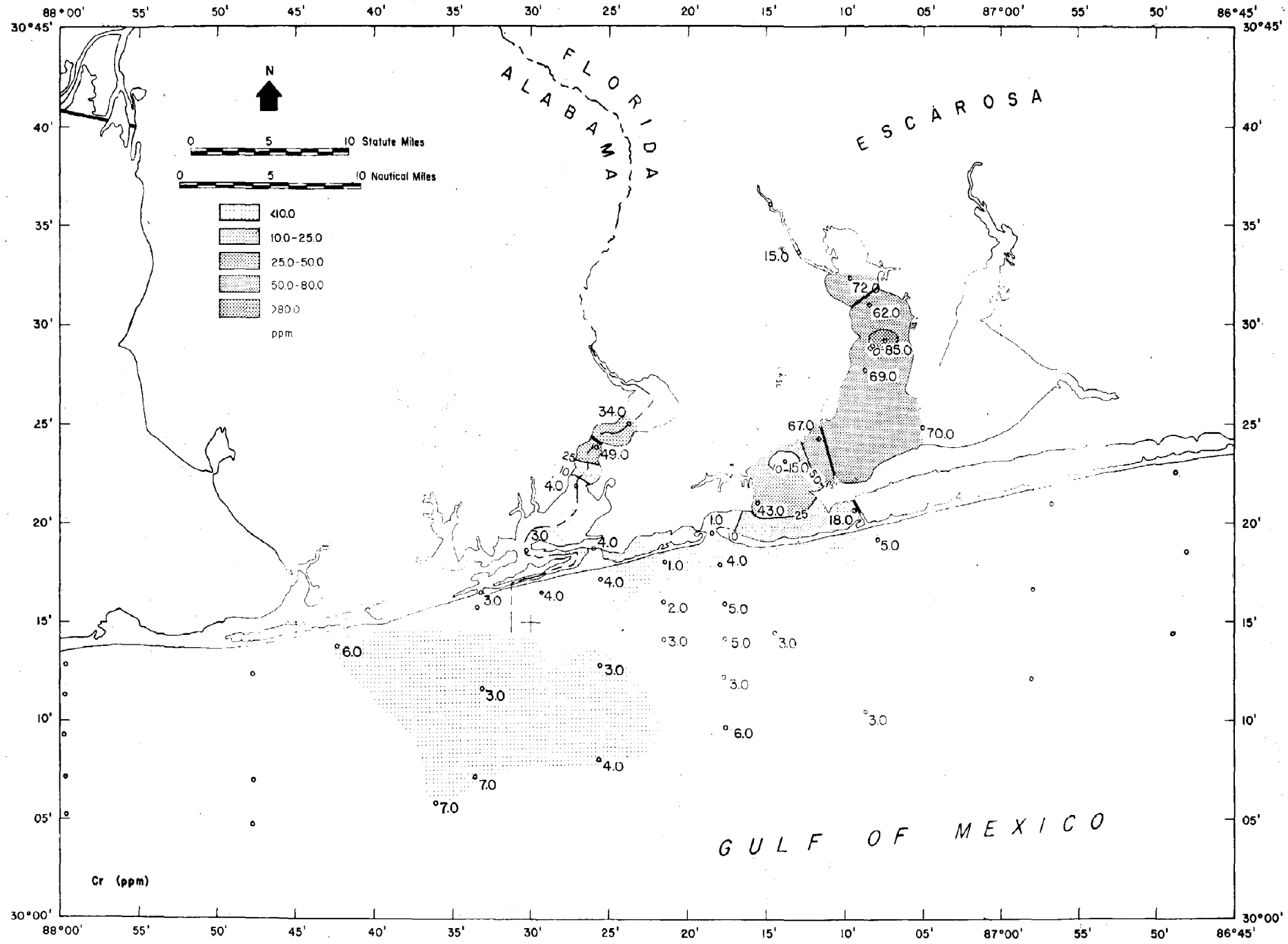


Figure 154 Distribution of Chromium in the Sediments

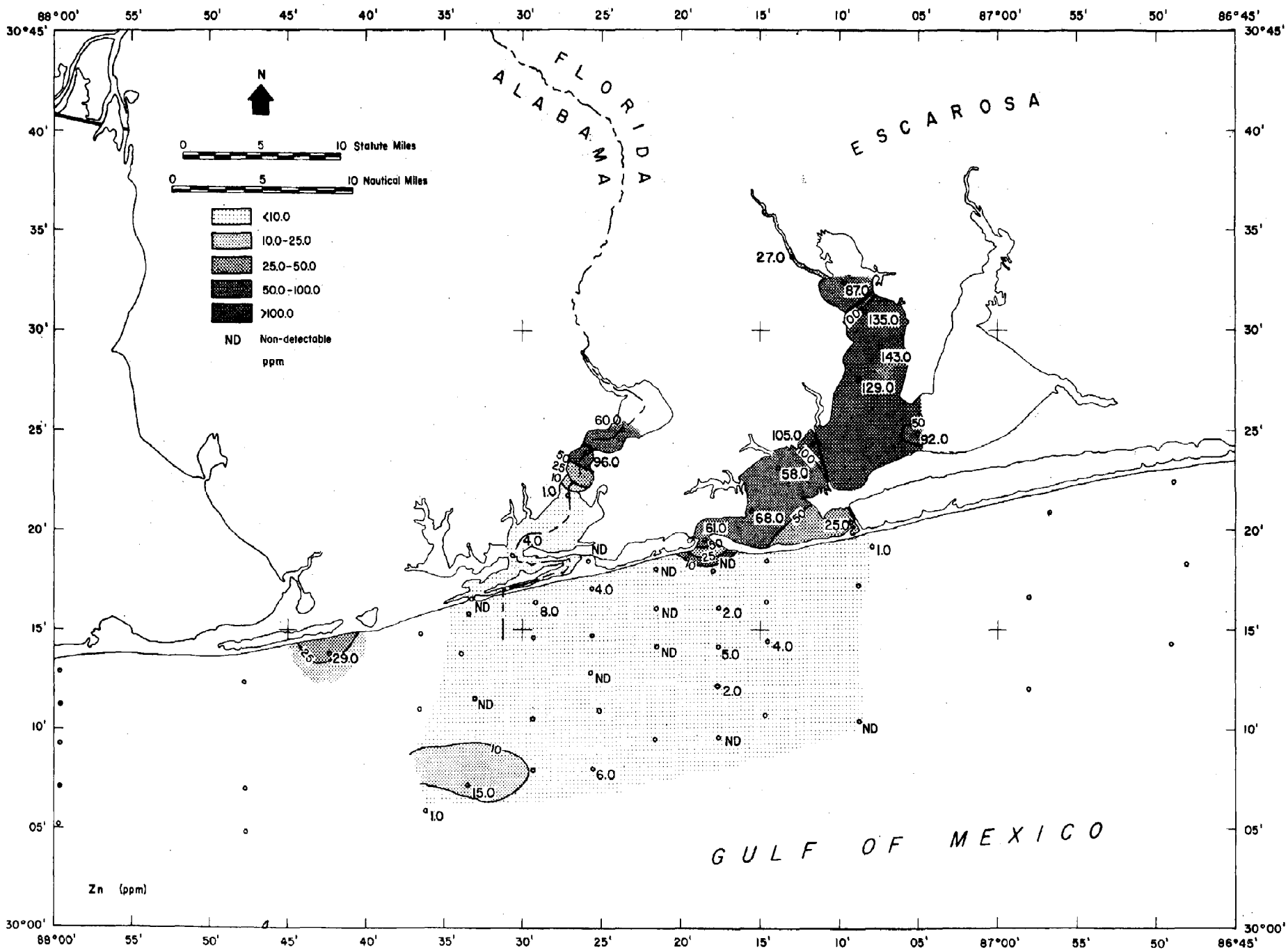


Figure 155 Distribution of Zinc in the Sediments

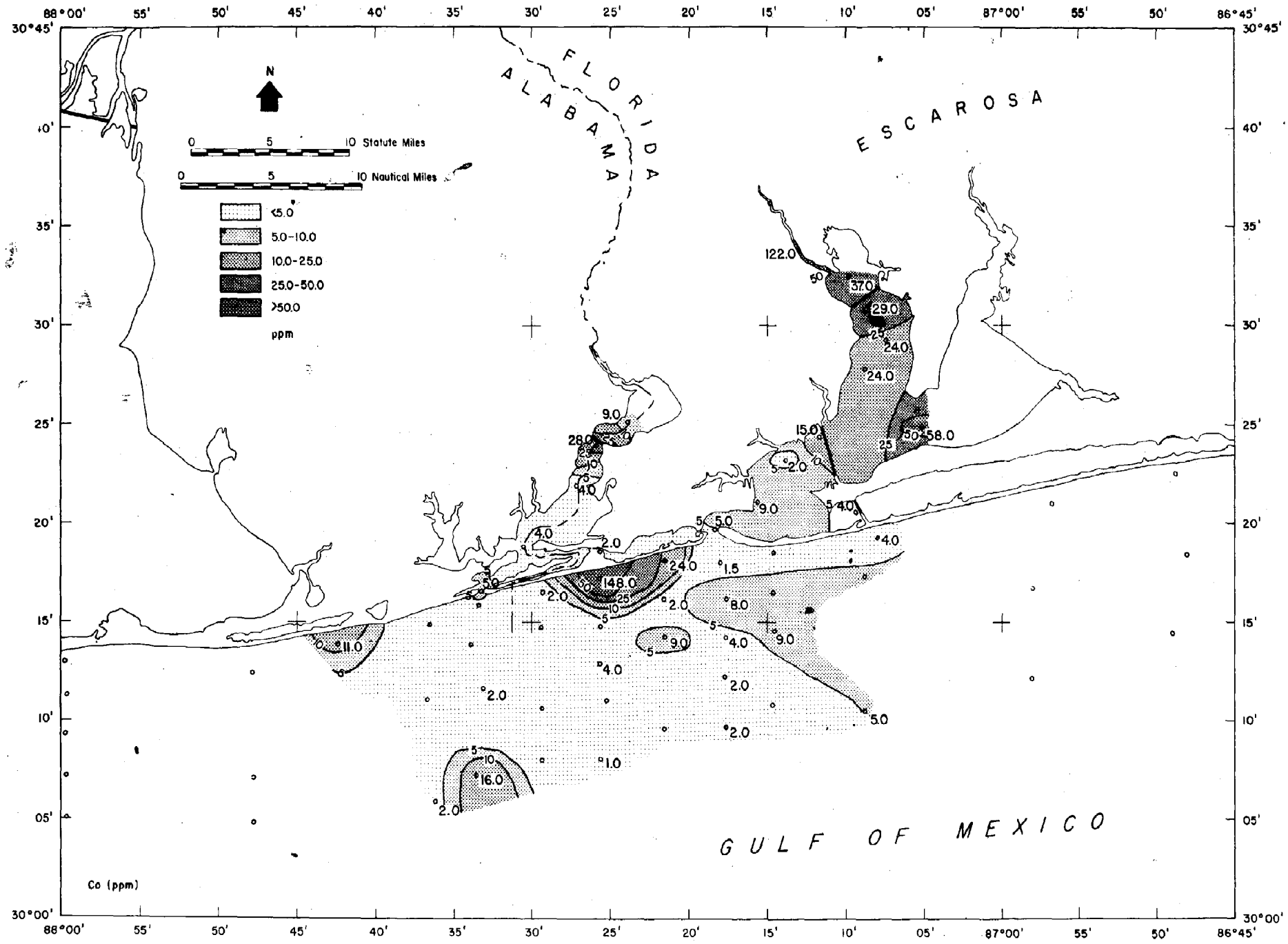


Figure 156 Distribution of Cobalt in the Sediments

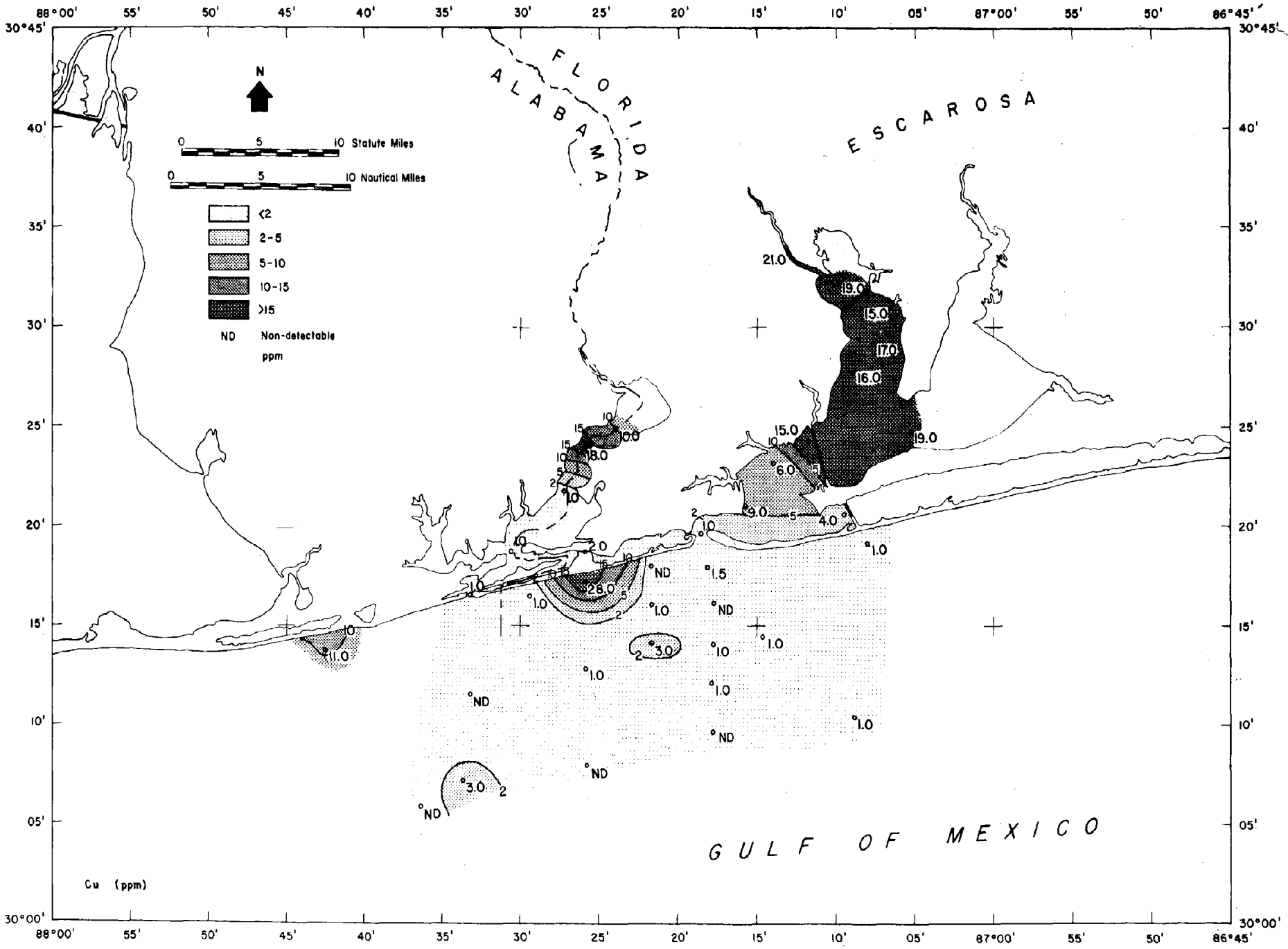


Figure 157 Distribution of Copper in the Sediments

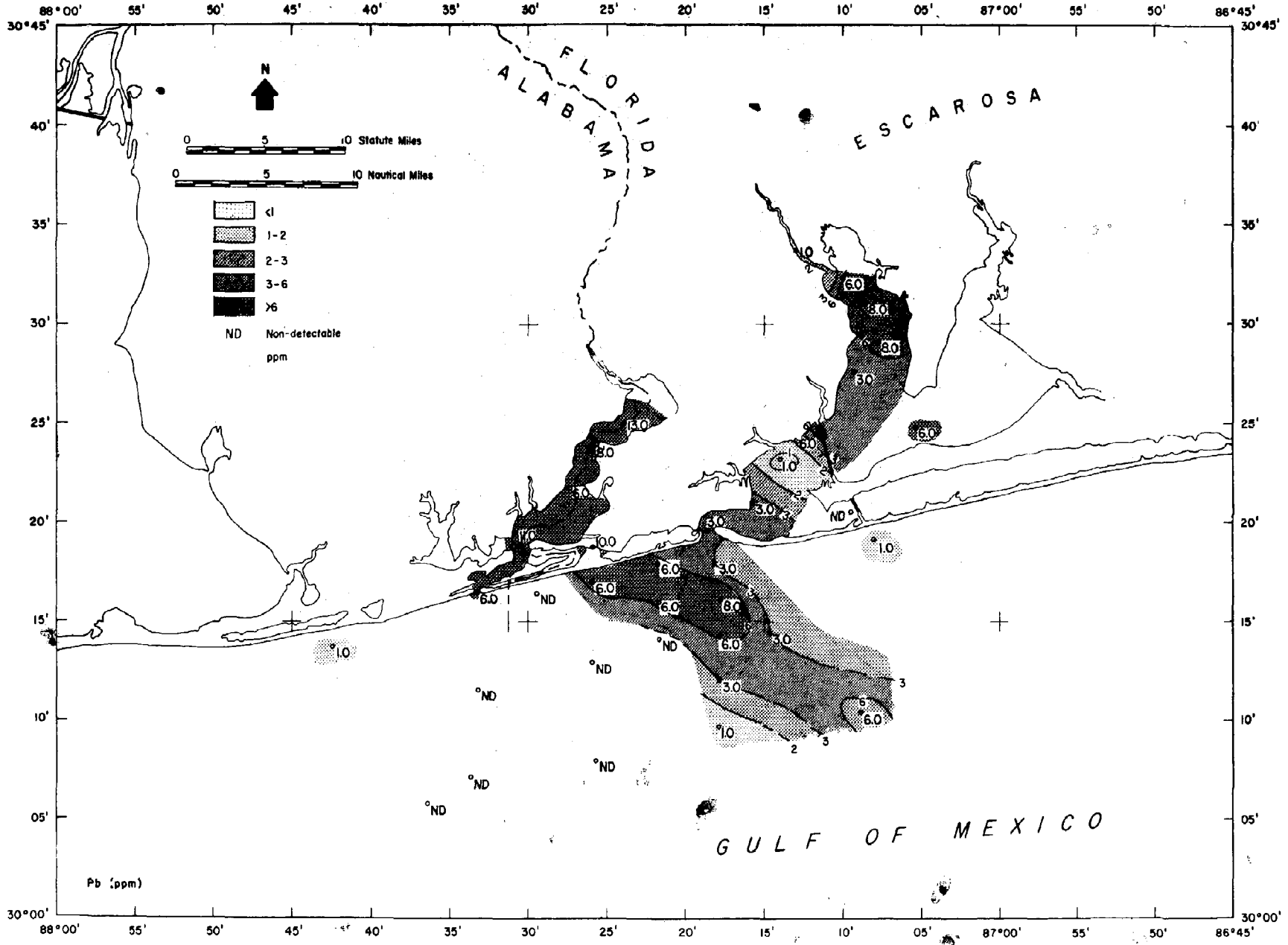


Figure 158 Distribution of Lead in the Sediments

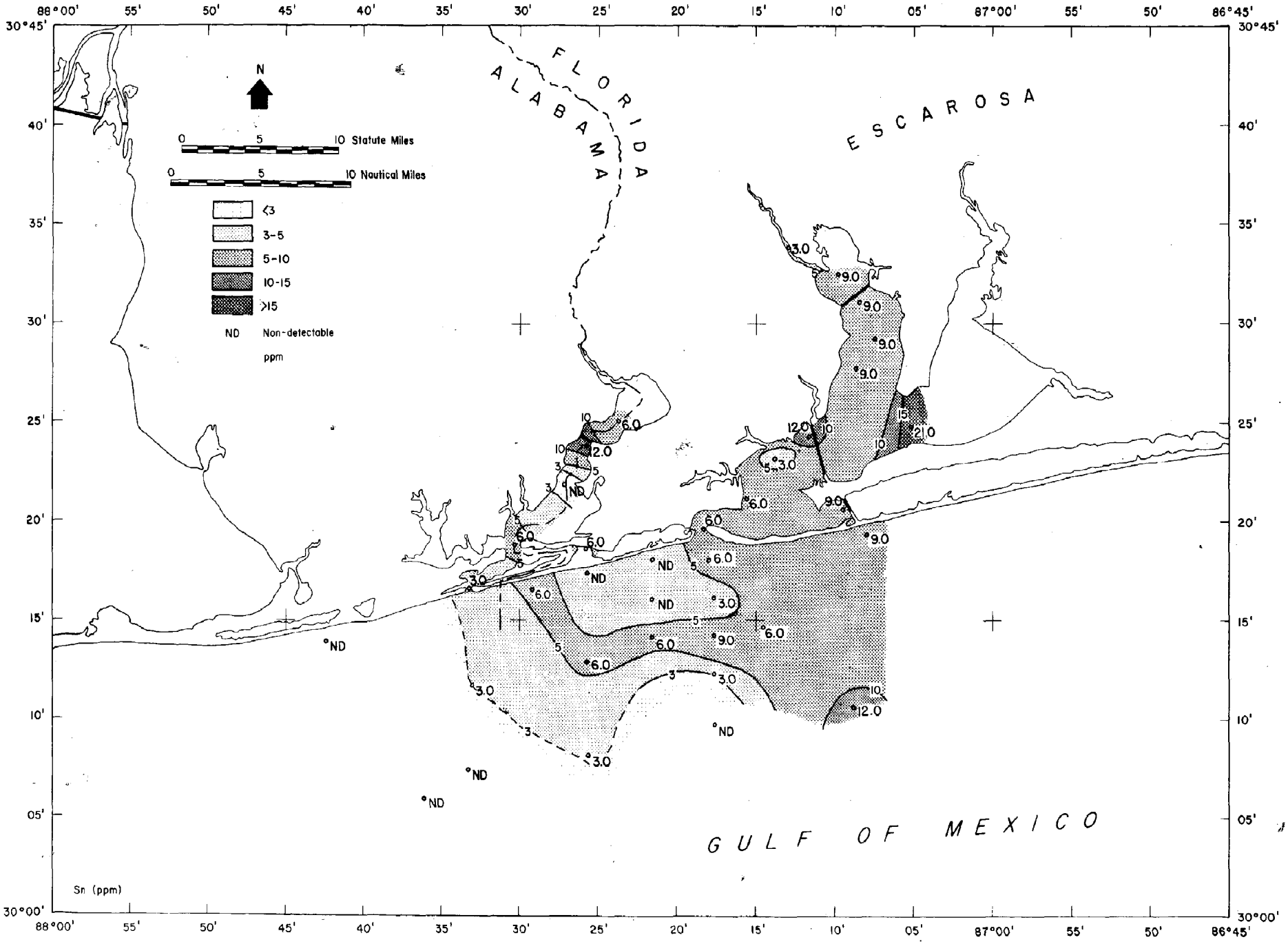


Figure 159 Distribution of Tin in the Sediments

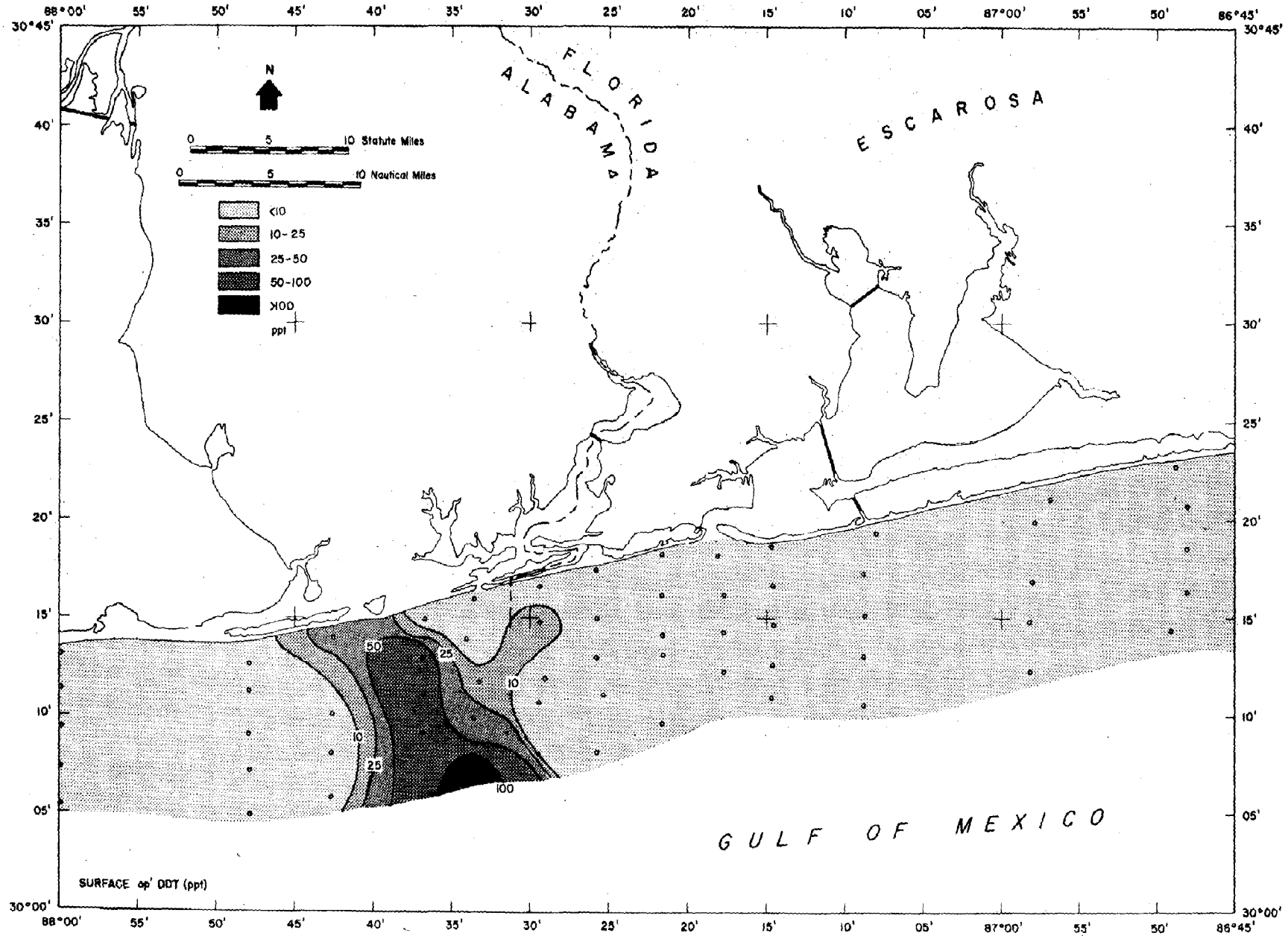


Figure 160 Surface op' DDT Distribution - September 14-16, 1971

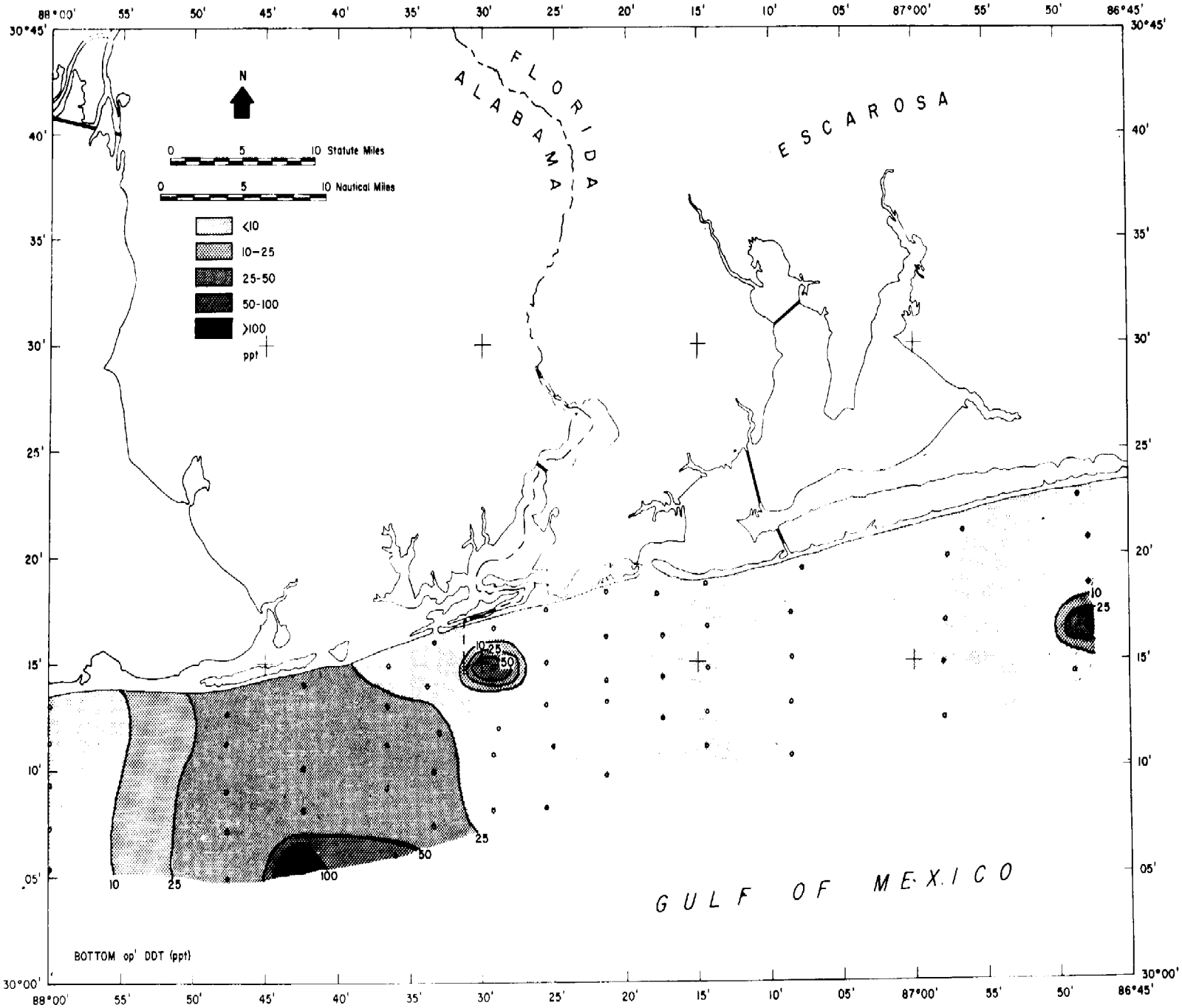


Figure 161 Bottom op' DDT Distribution - September 14-16, 1971

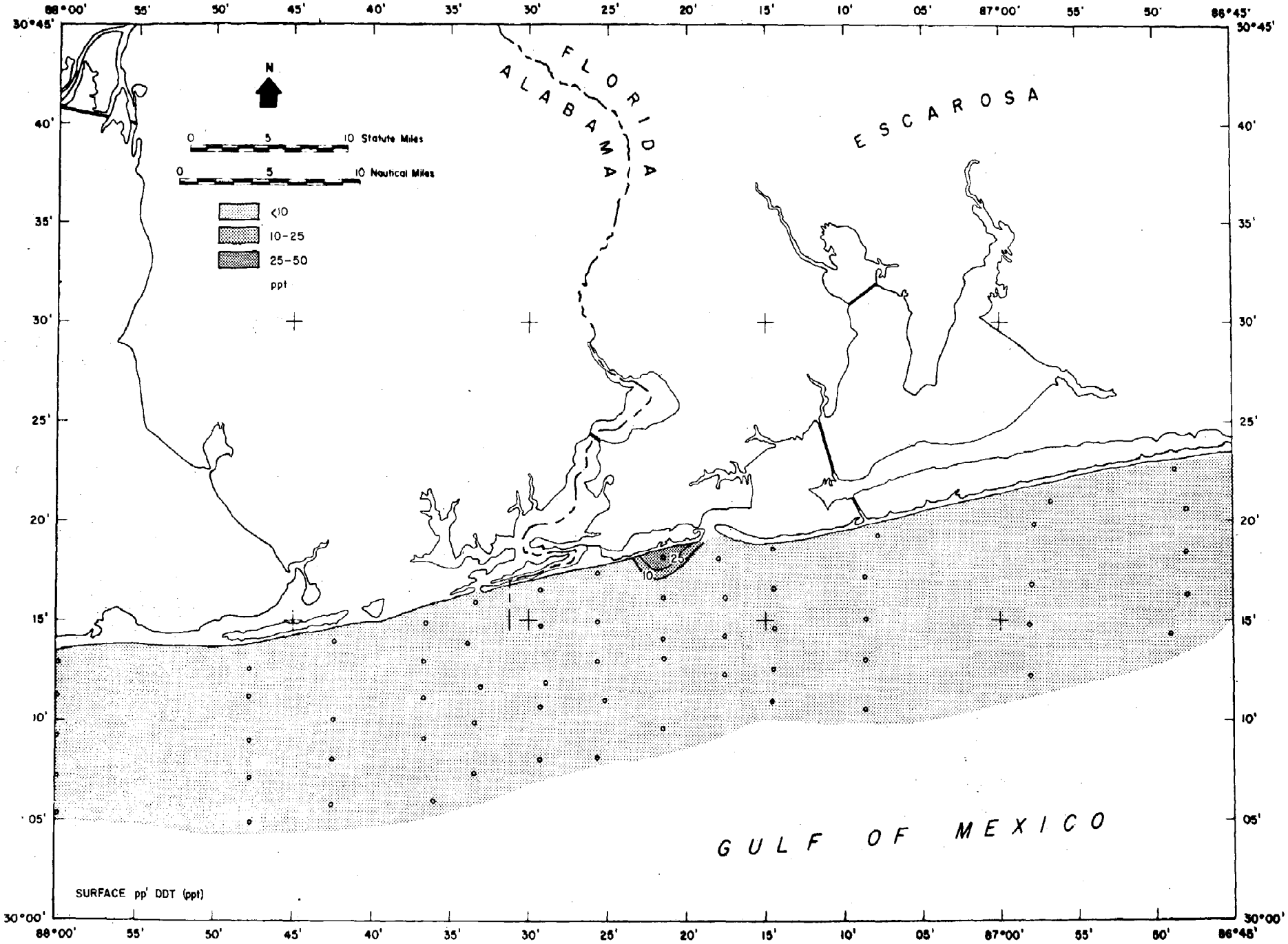


Figure 162 Surface pp' DDT Distribution - September 14-16, 1971

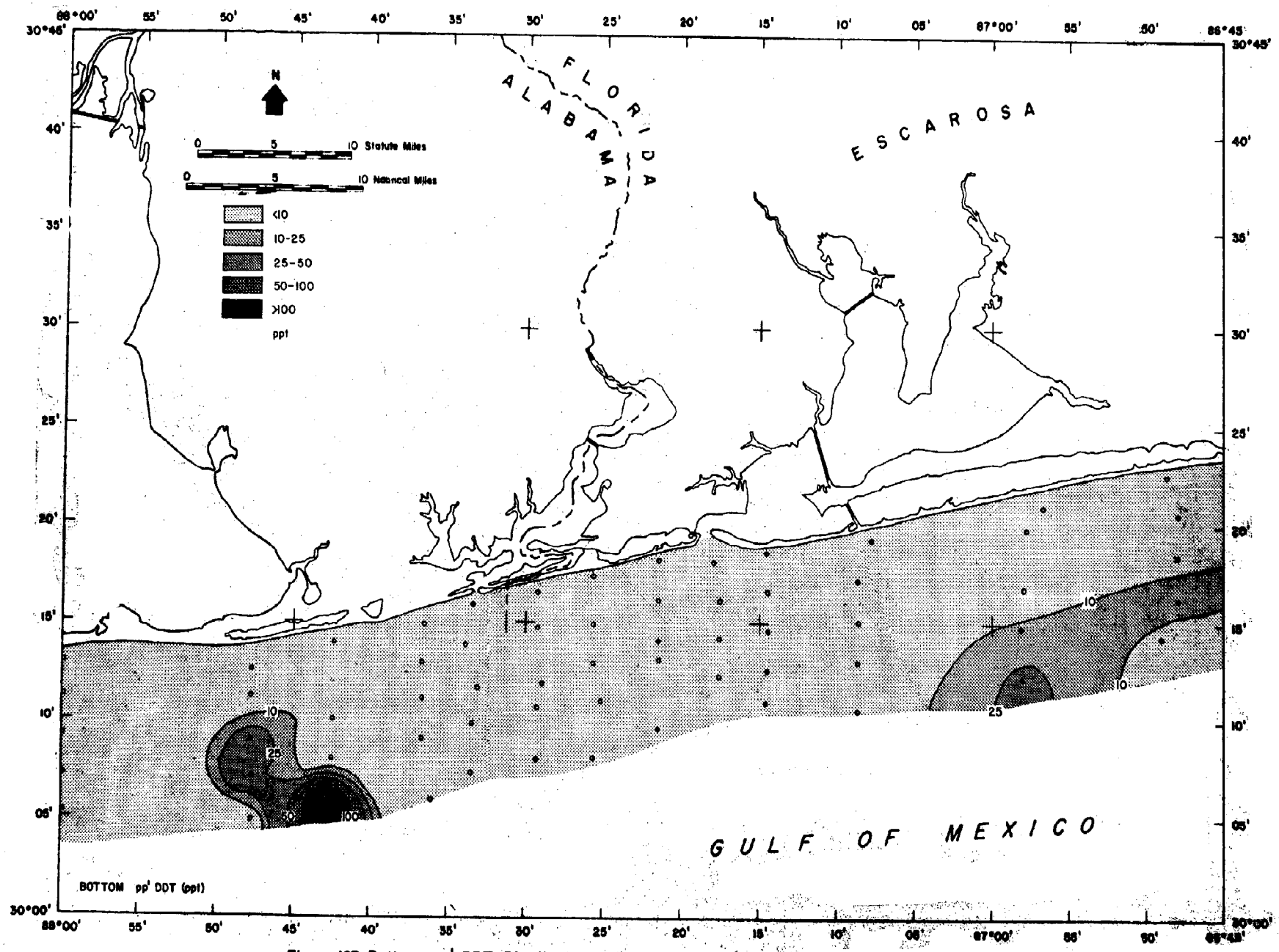


Figure 163 Bottom pp' DDT Distribution - September 14-16, 1971

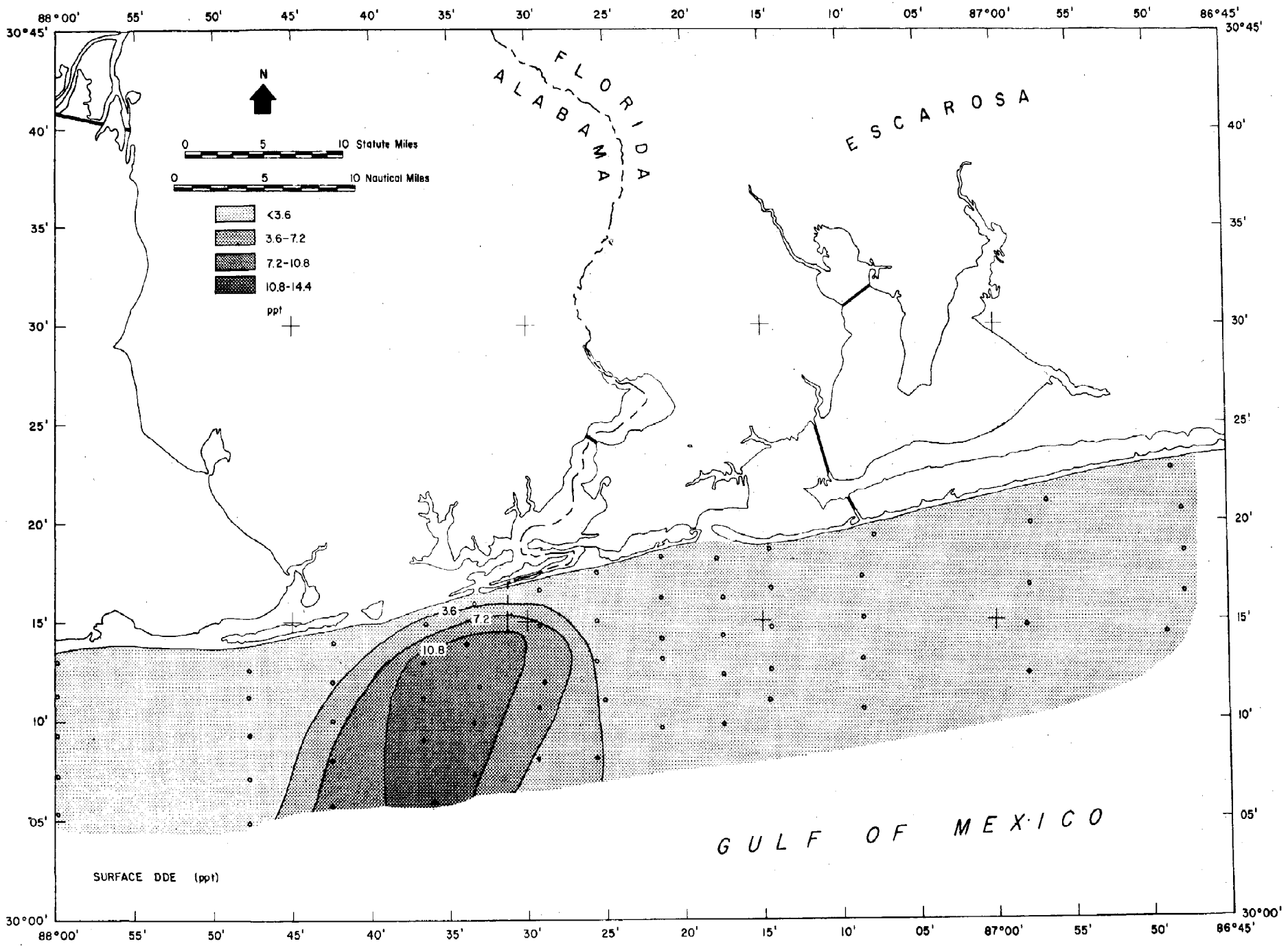


Figure 164 Surface DDE Distribution – September 14-16, 1971

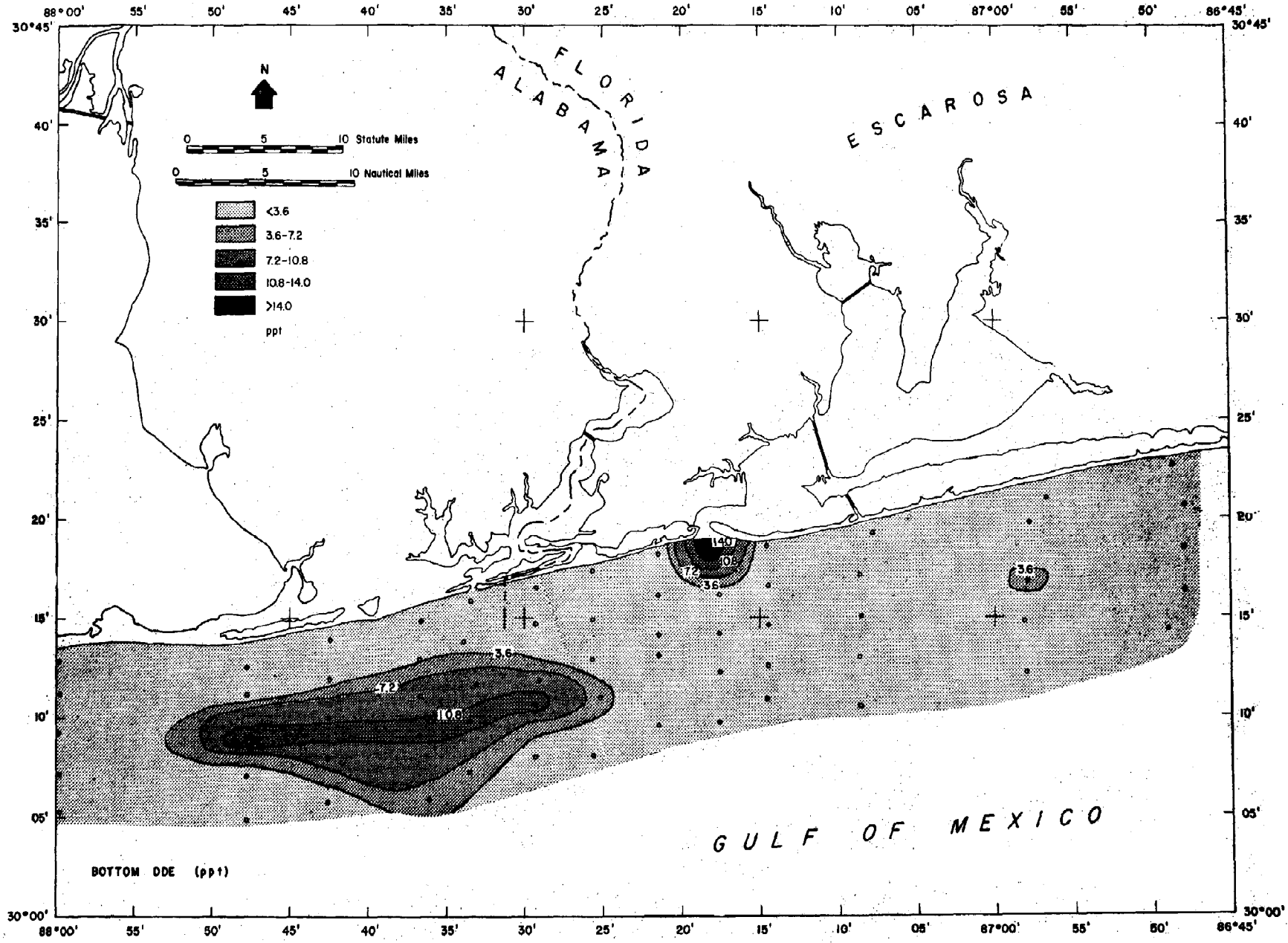


Figure 165 Bottom DDE Distribution - September 14-16, 1971

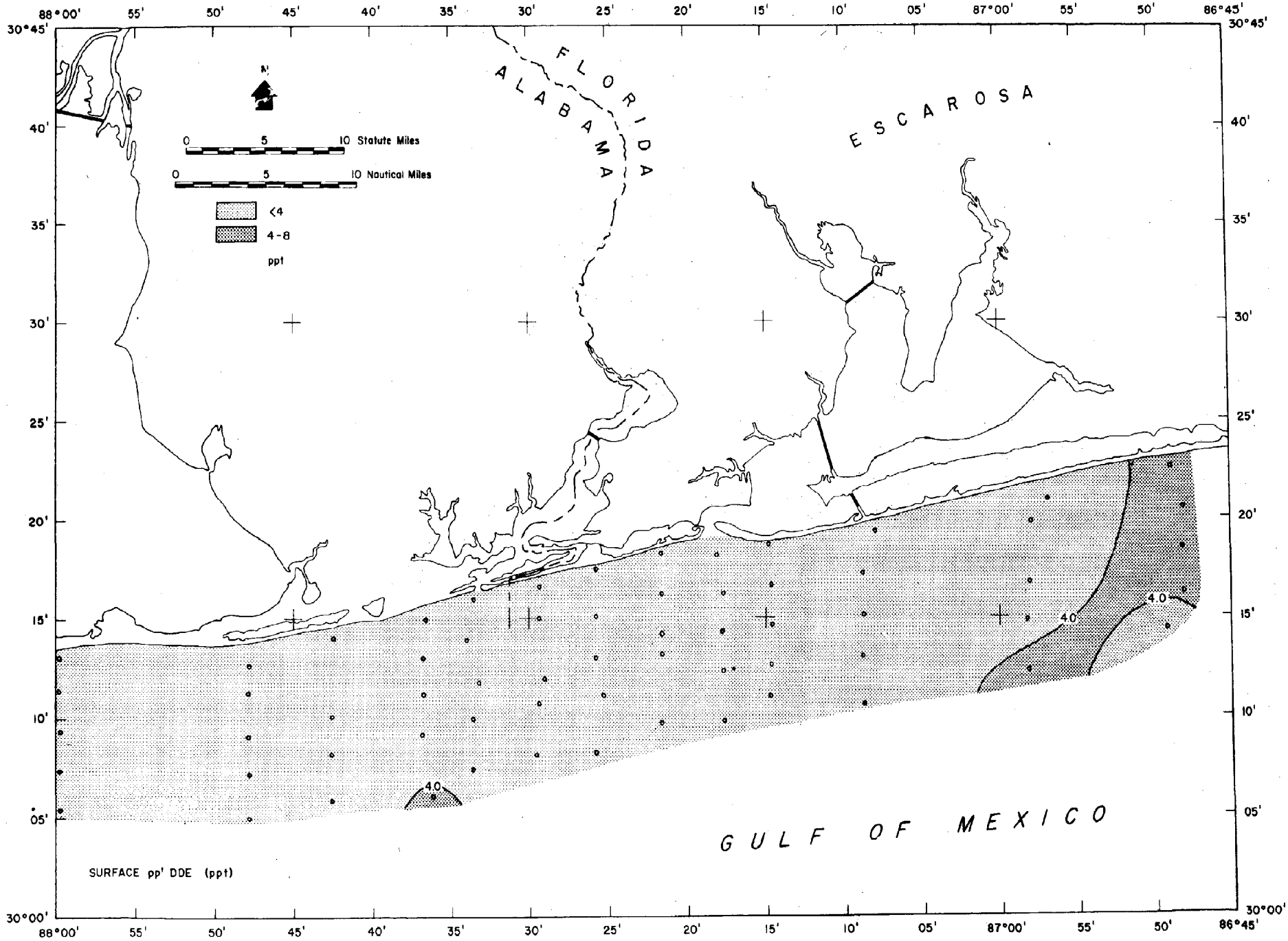


Figure 166 Surface pp' DDE Distribution - September 14-16, 1971

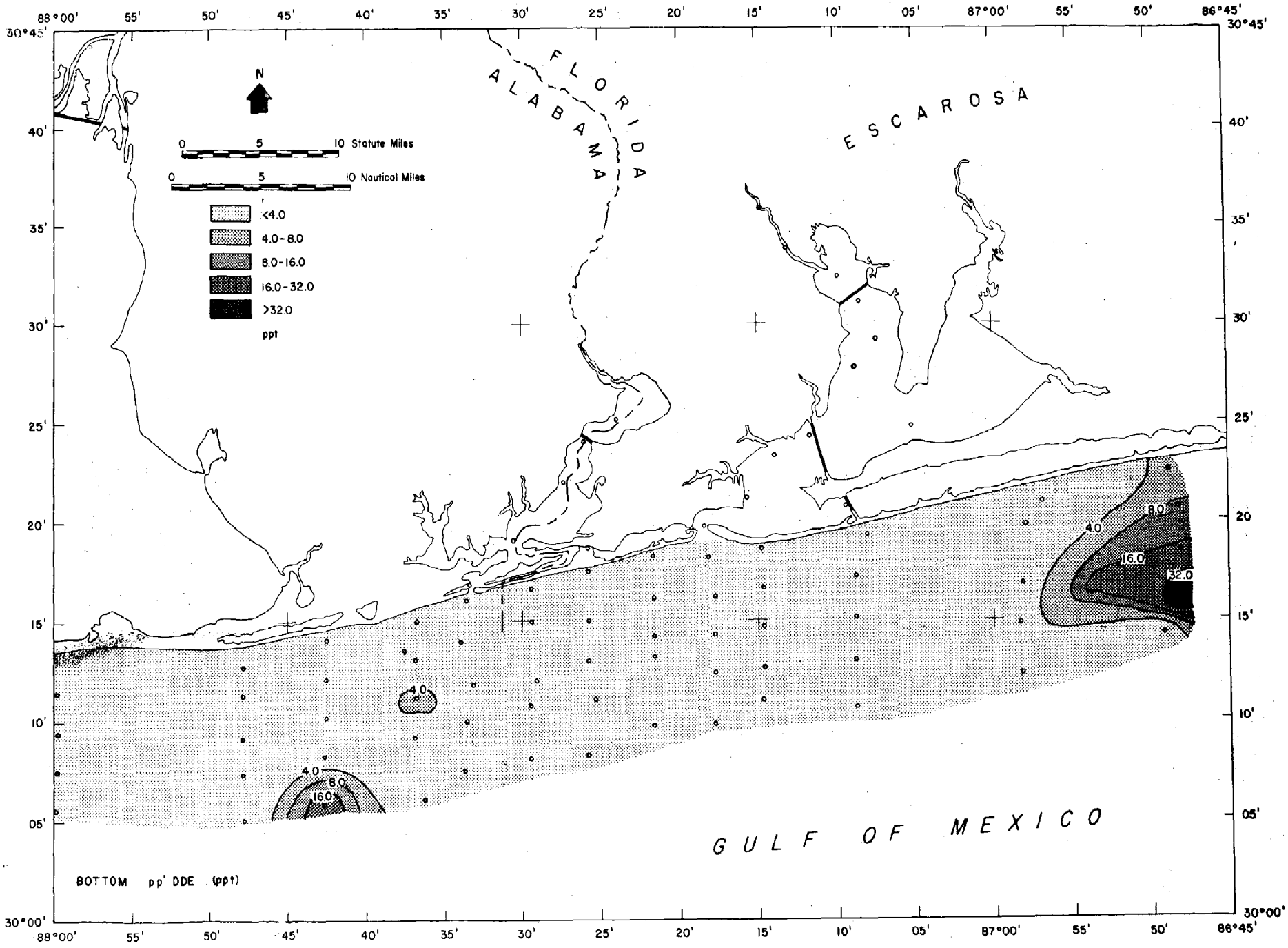


Figure 167 Bottom pp DDE Distribution - September 14-16, 1971

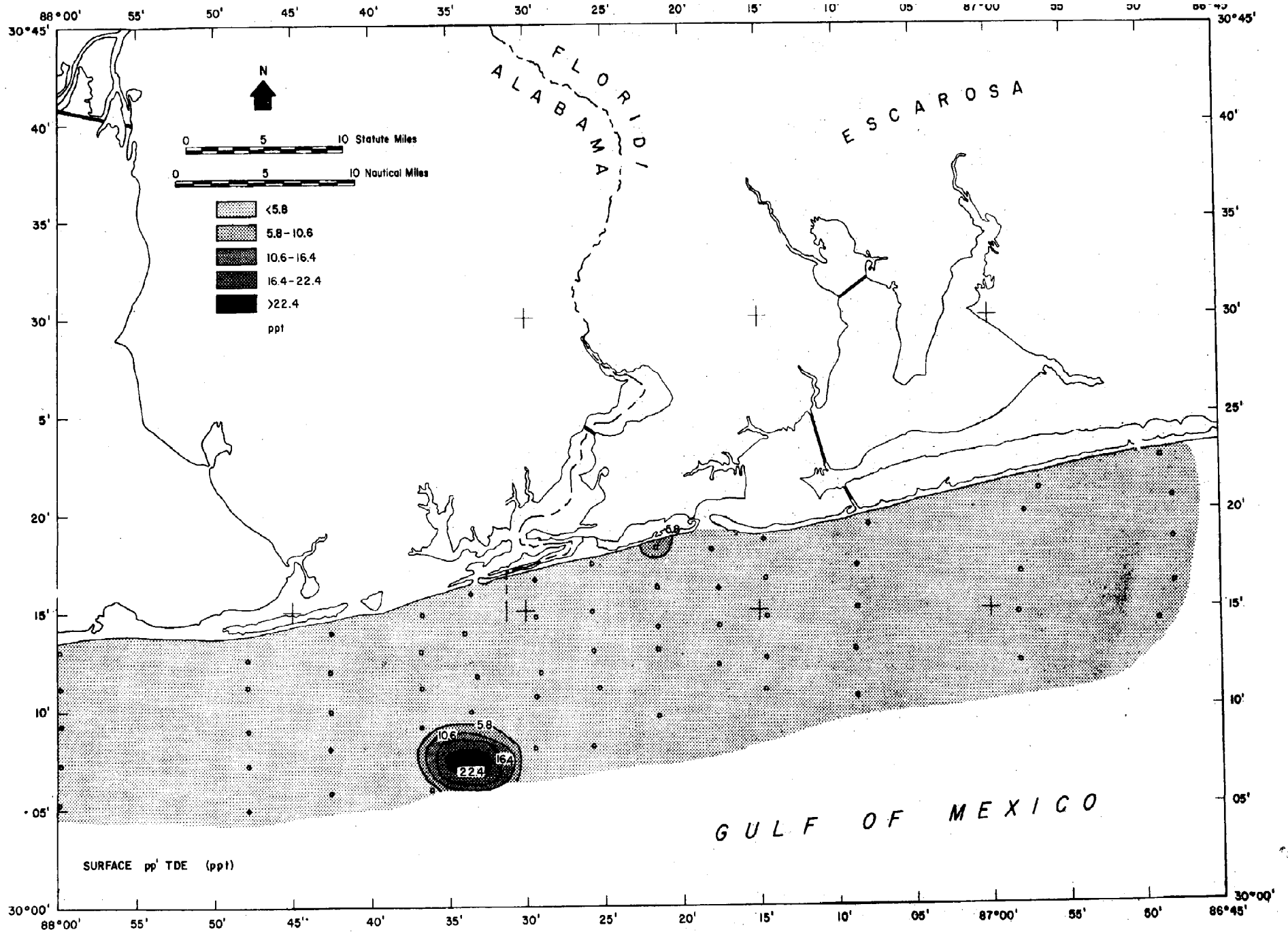


Figure 168 Surface pp' TDE Distribution - September 14-16, 1971

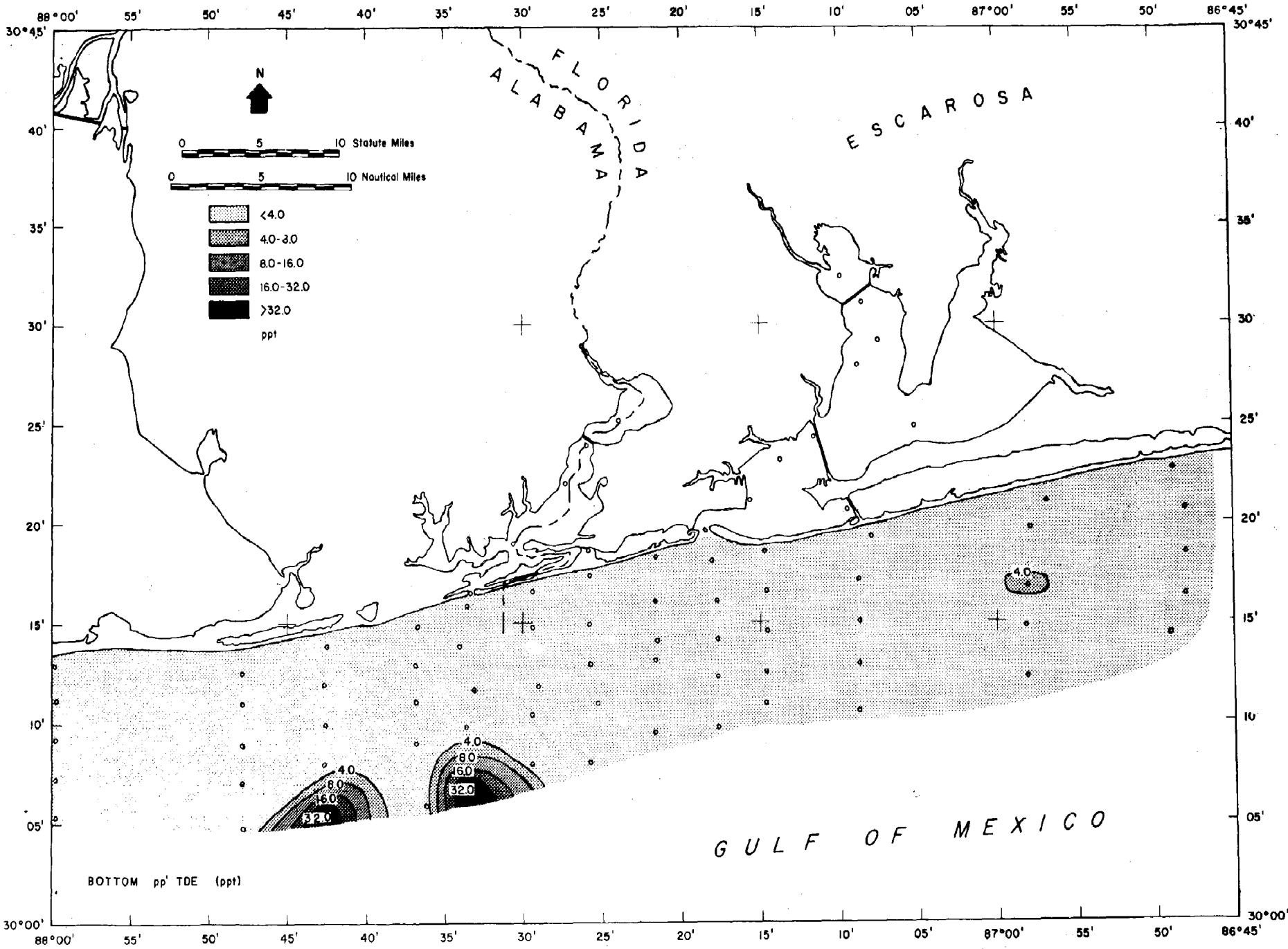


Figure 169 Bottom pp' TDE Distribution - September 14-16, 1971

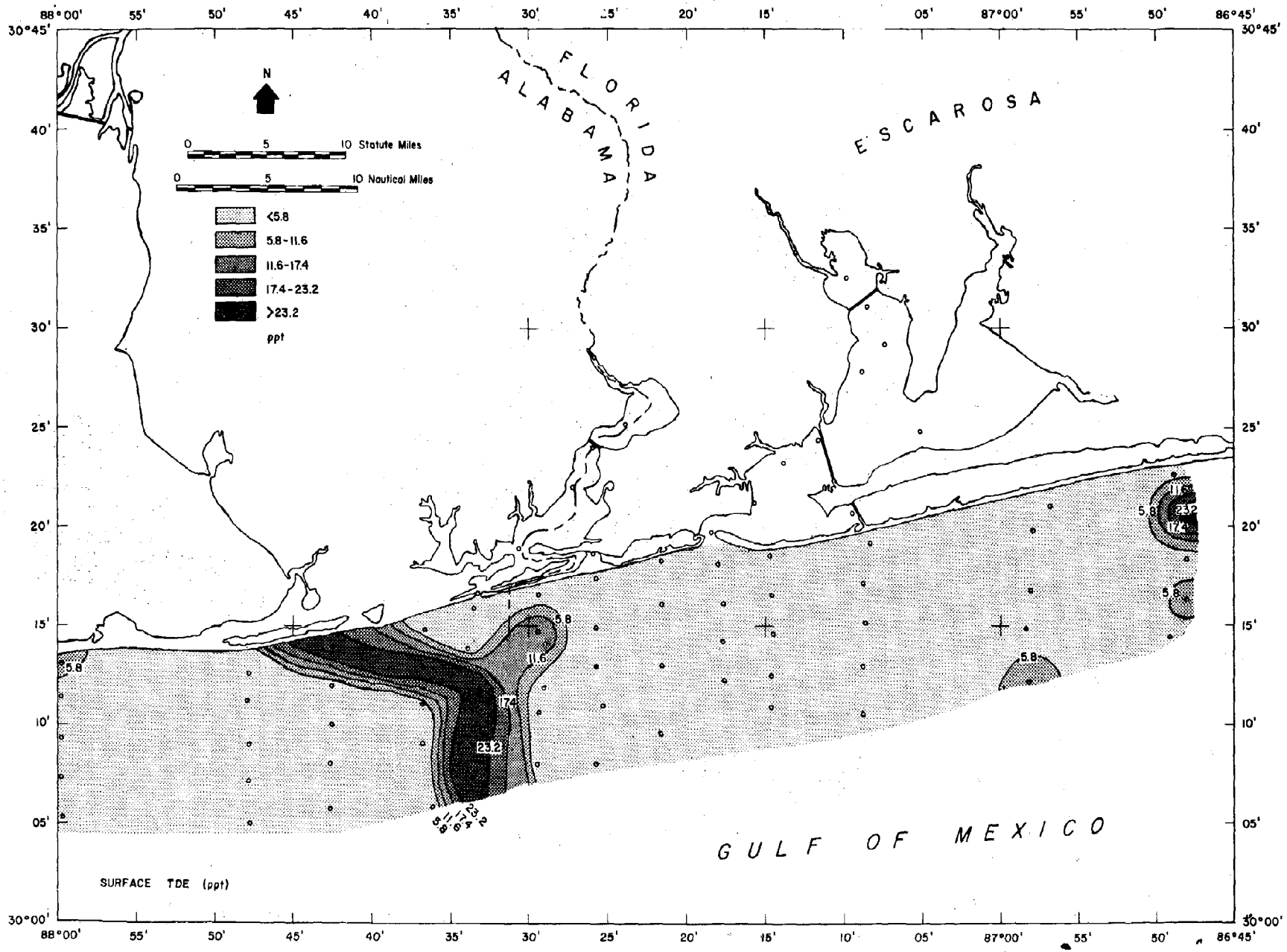


Figure 170 Surface TDE Distribution - September 14-16, 1971

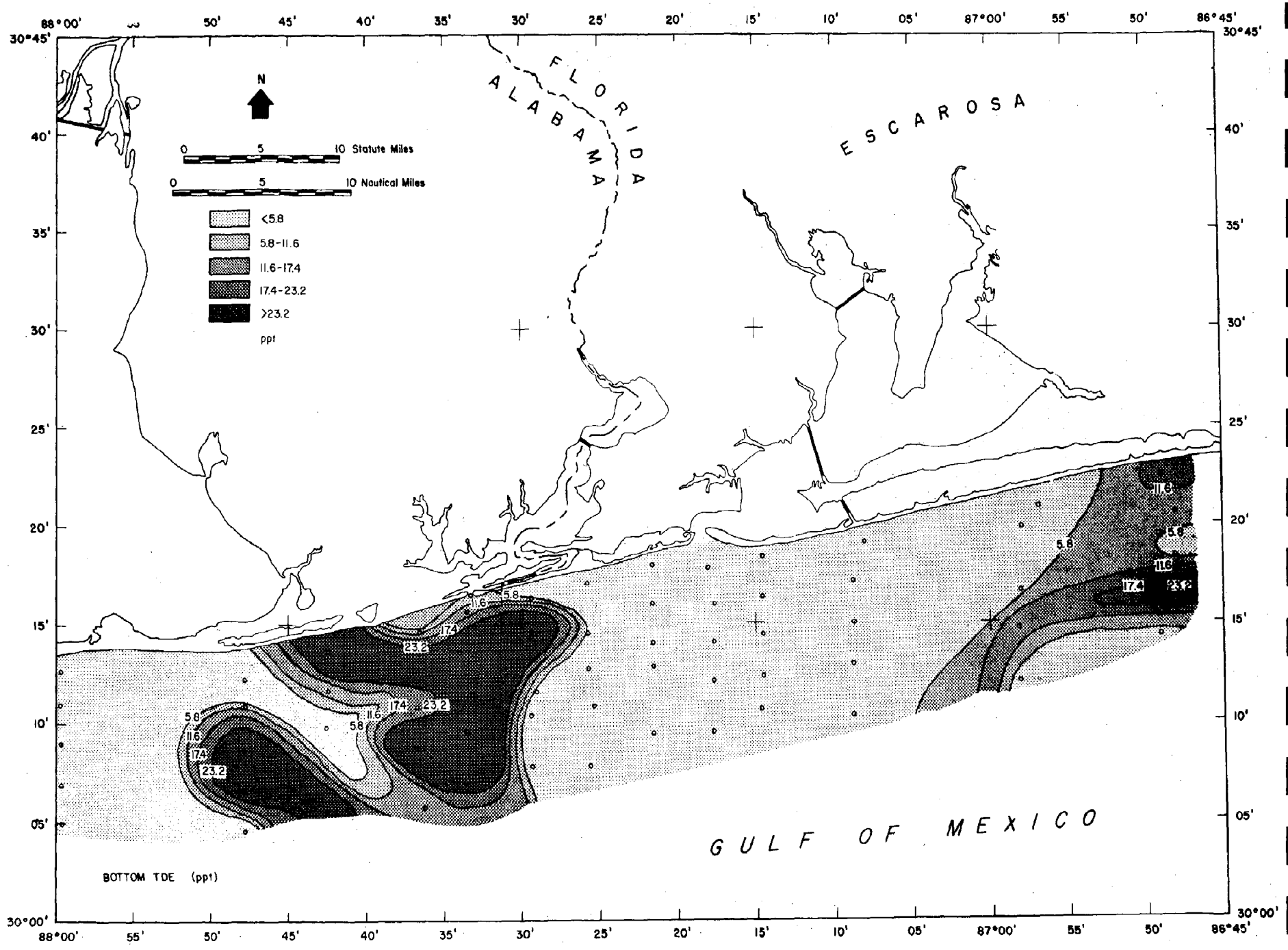


Figure 171 Bottom TDE Distribution - September 14-16, 1971

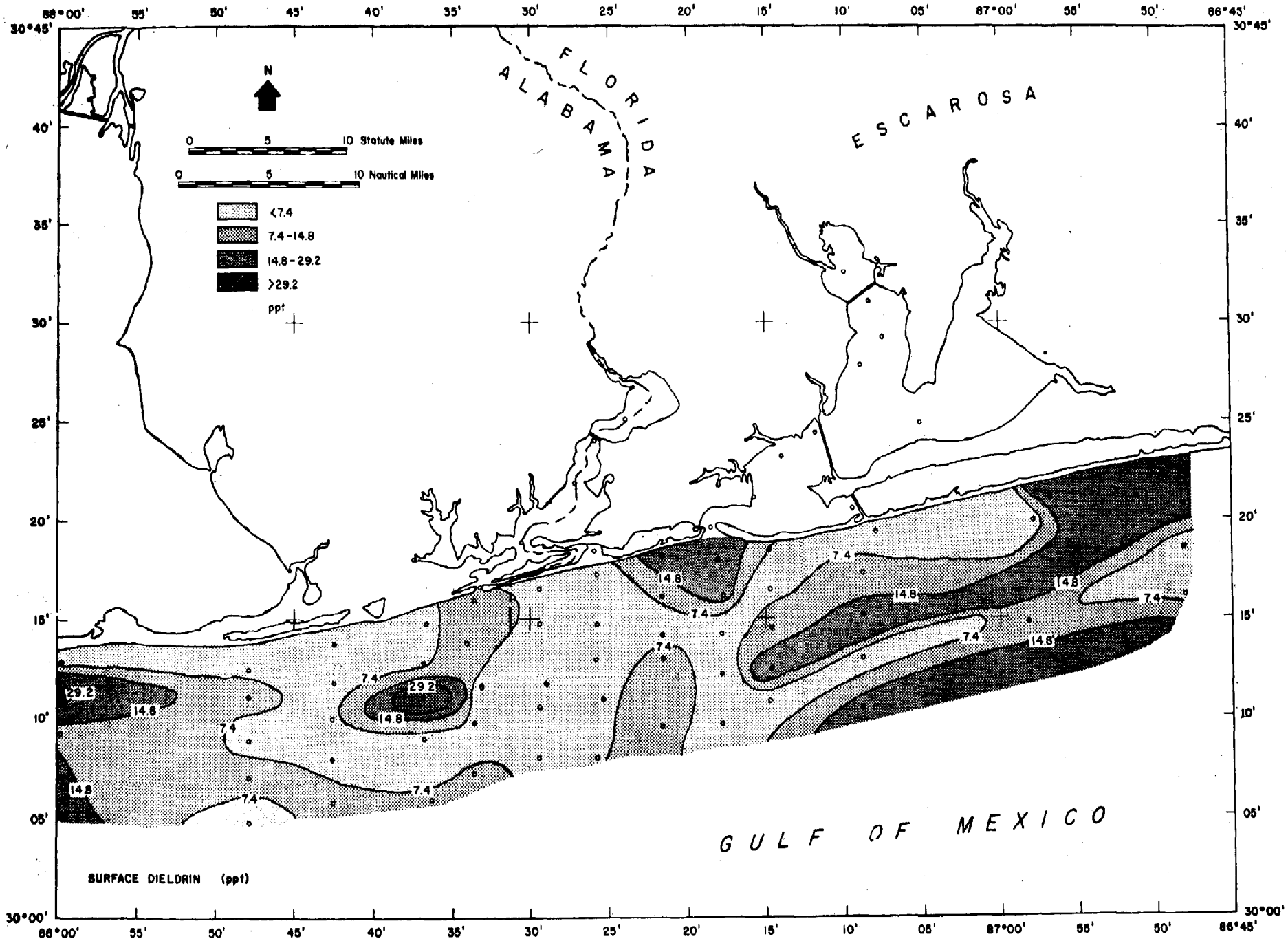


Figure 172 Surface Dieldrin Distribution - September 14-16, 1971

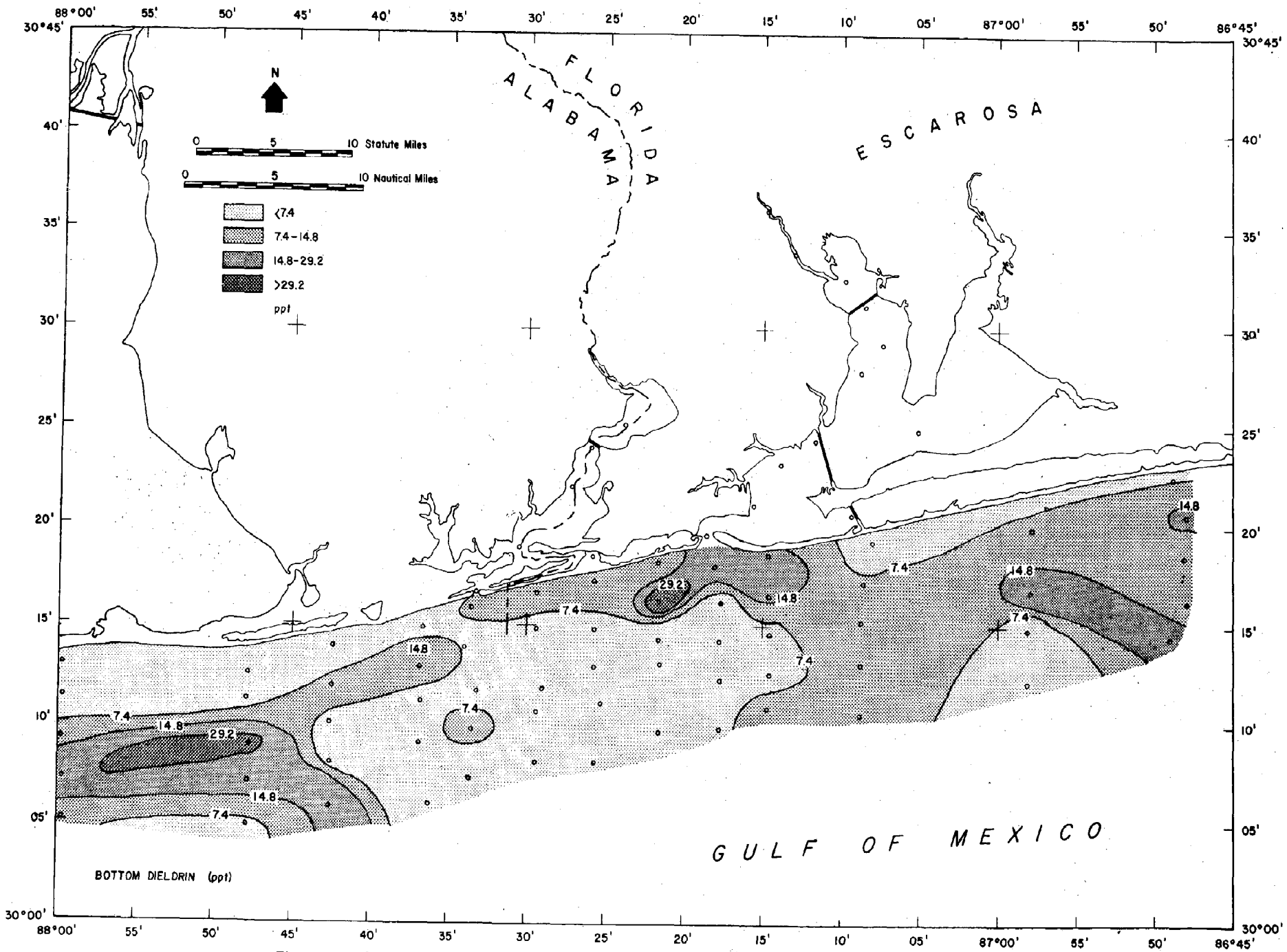


Figure 173 Bottom Dieldrin Distribution – September 14-16, 1971

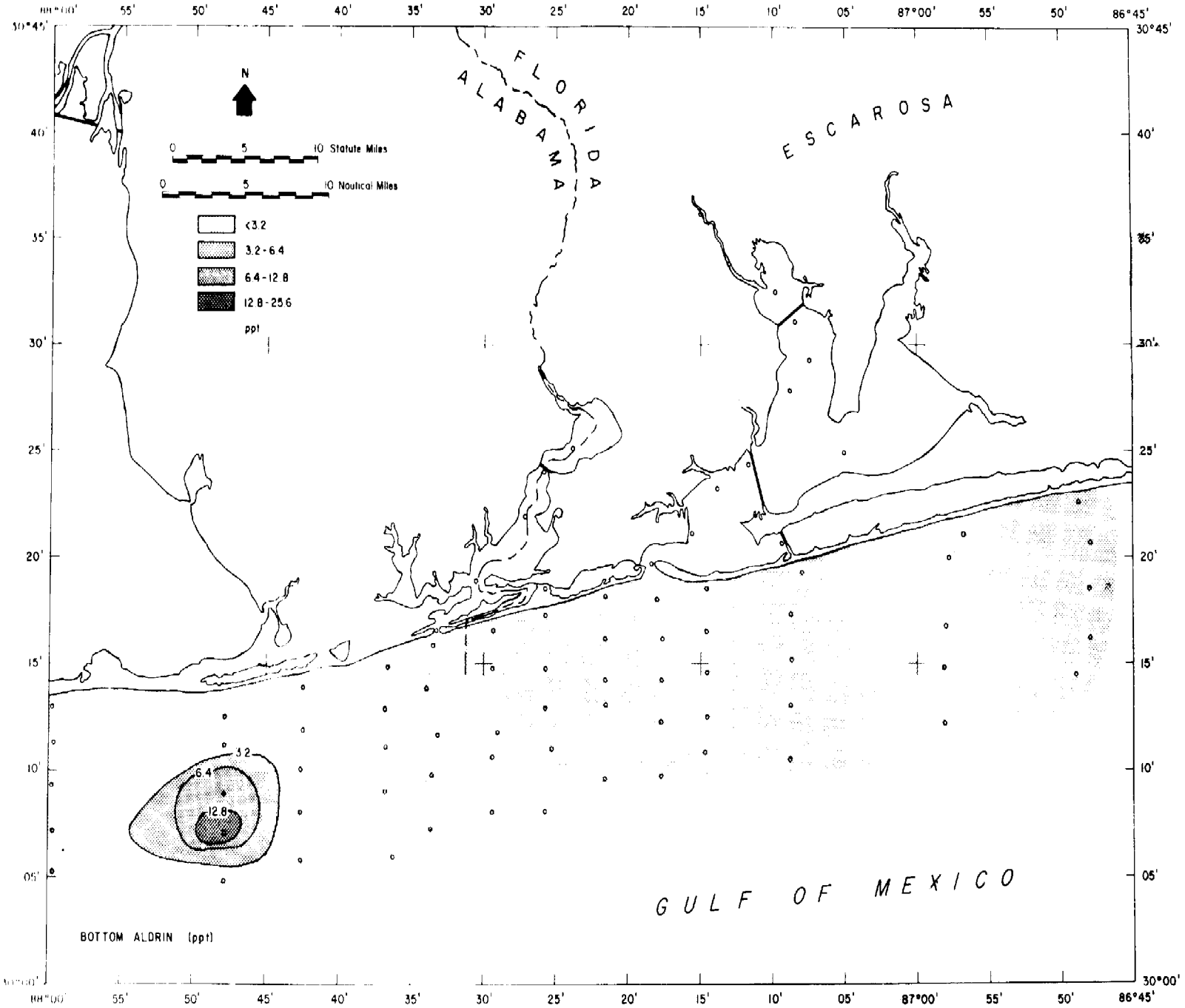


Figure 174 Bottom Aldrin Distribution – September 14-16, 1971

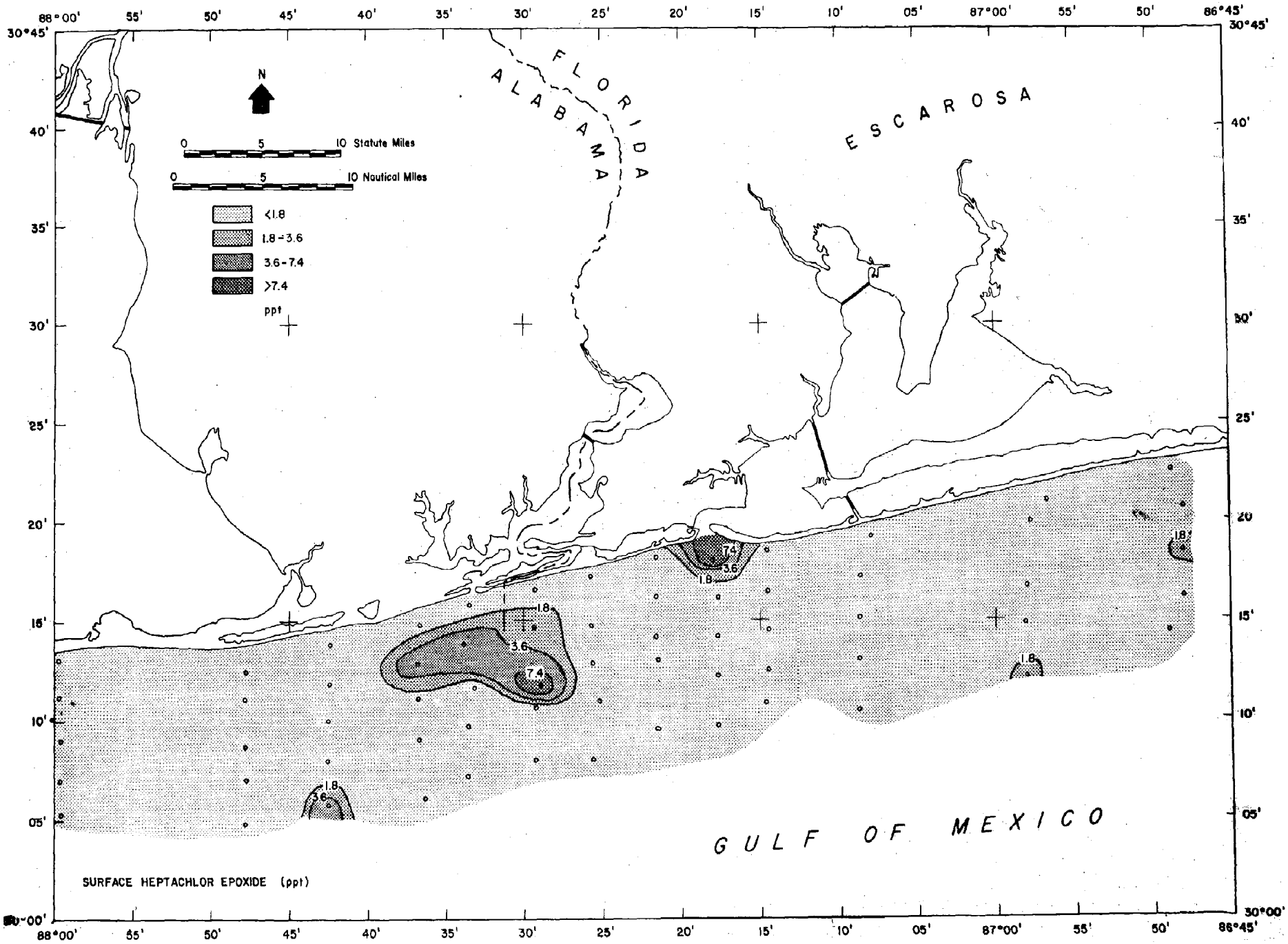


Figure 175 Surface Heptachlor Epoxide Distribution – September 14–16, 1971

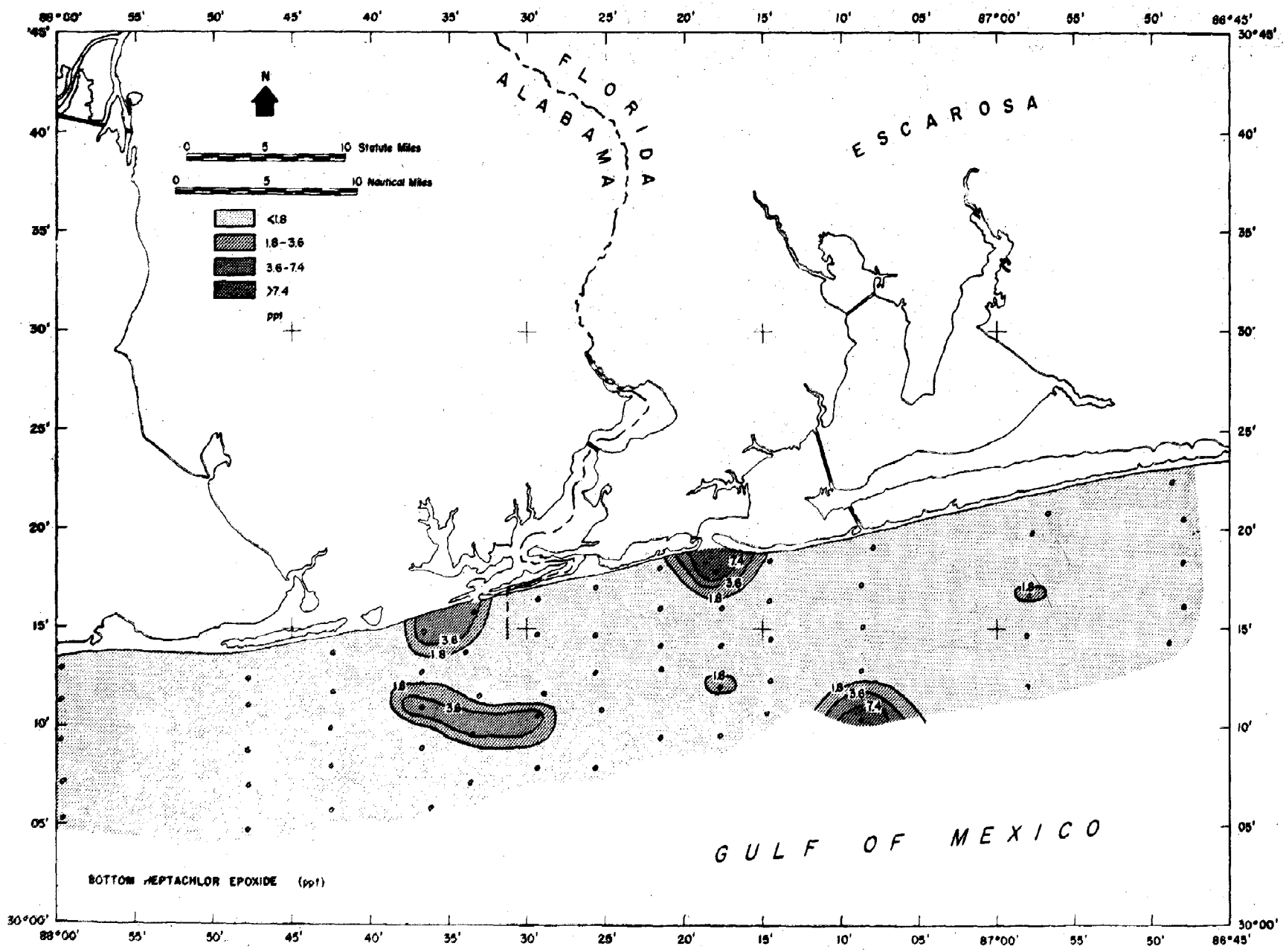


Figure 176 Bottom Heptachlor Epoxide Distribution – September 14-16, 1971

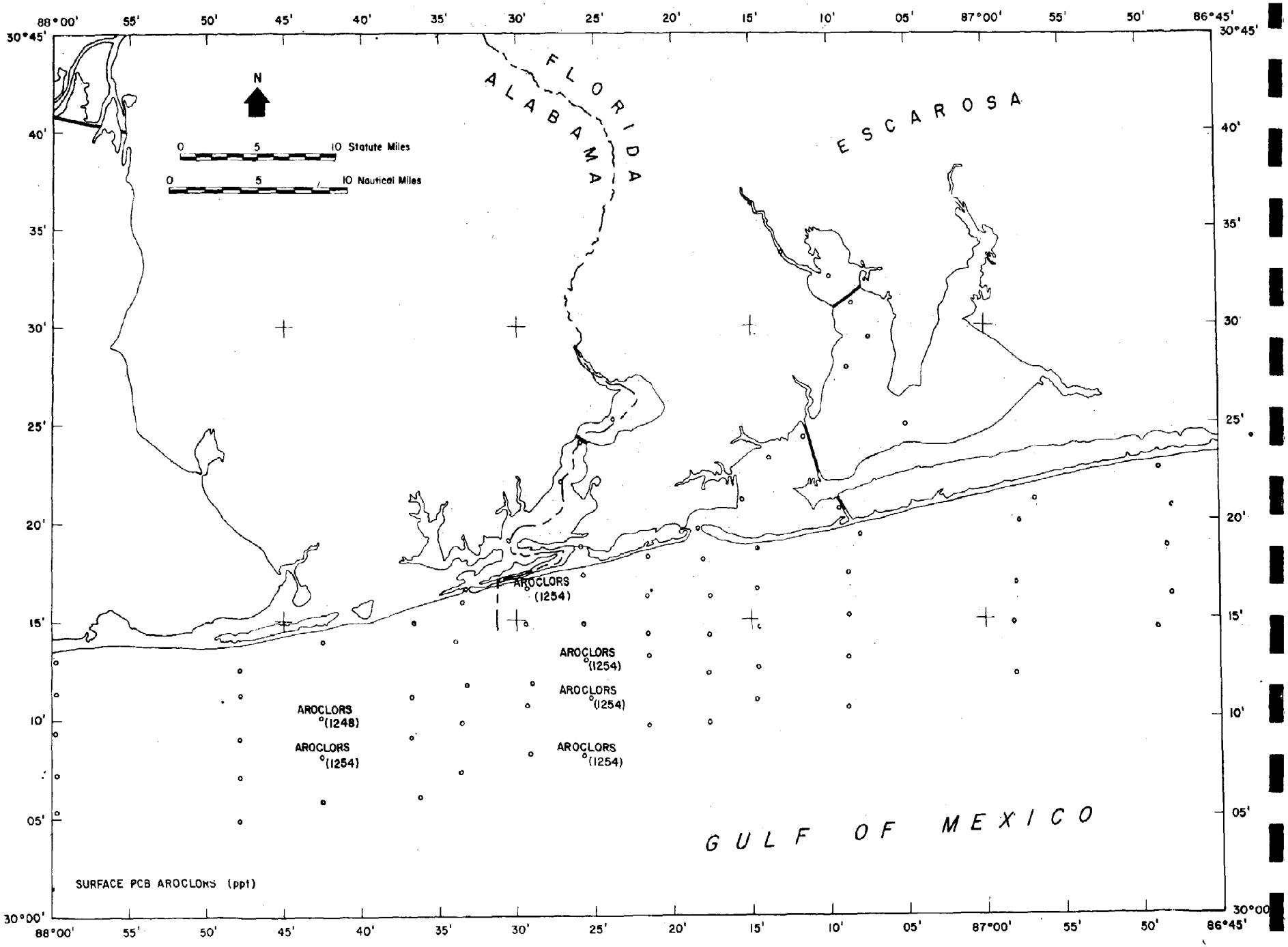


Figure 177 Surface PCB Aroclors

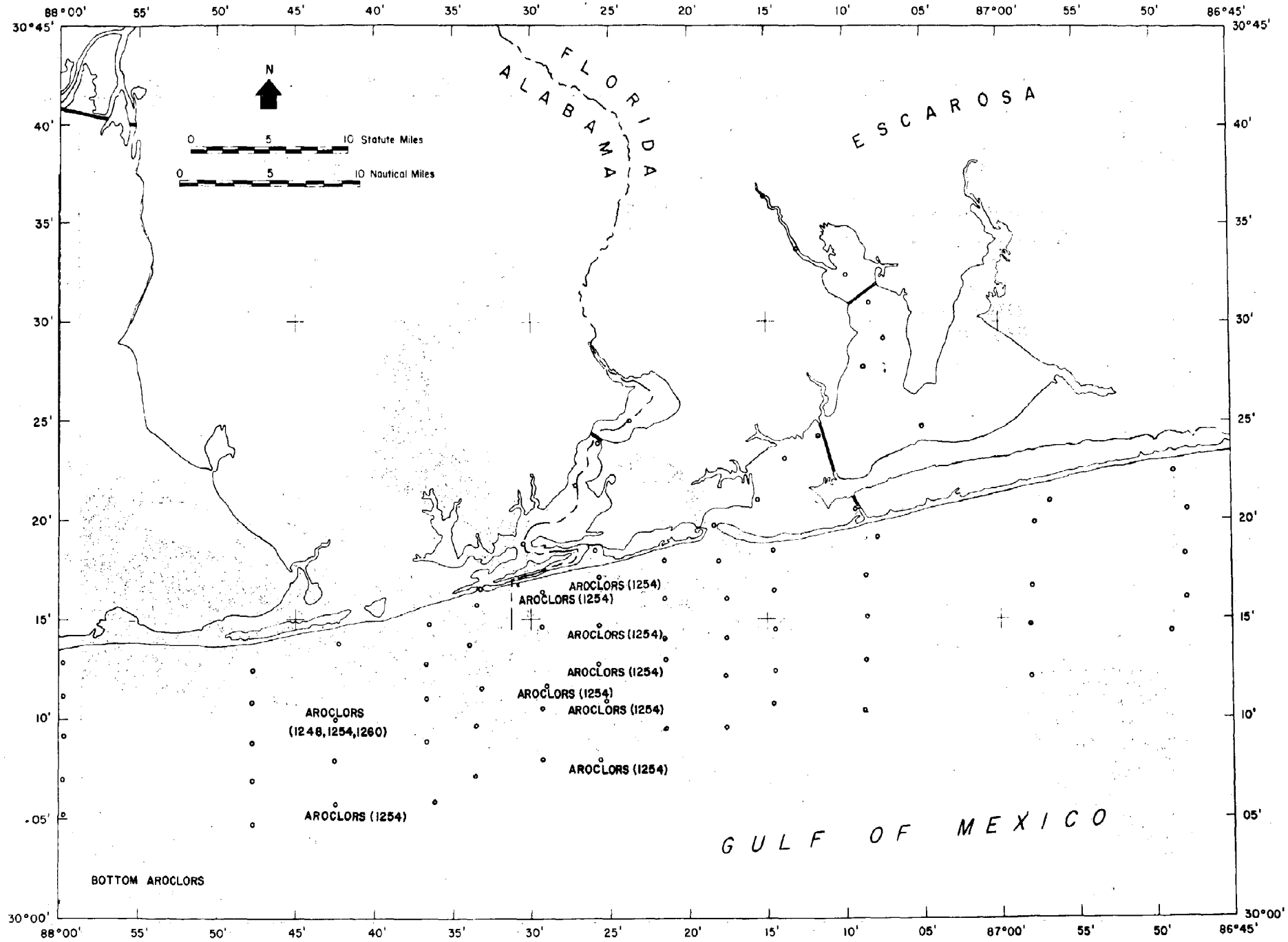


Figure 178 Bottom PCB Aroclors

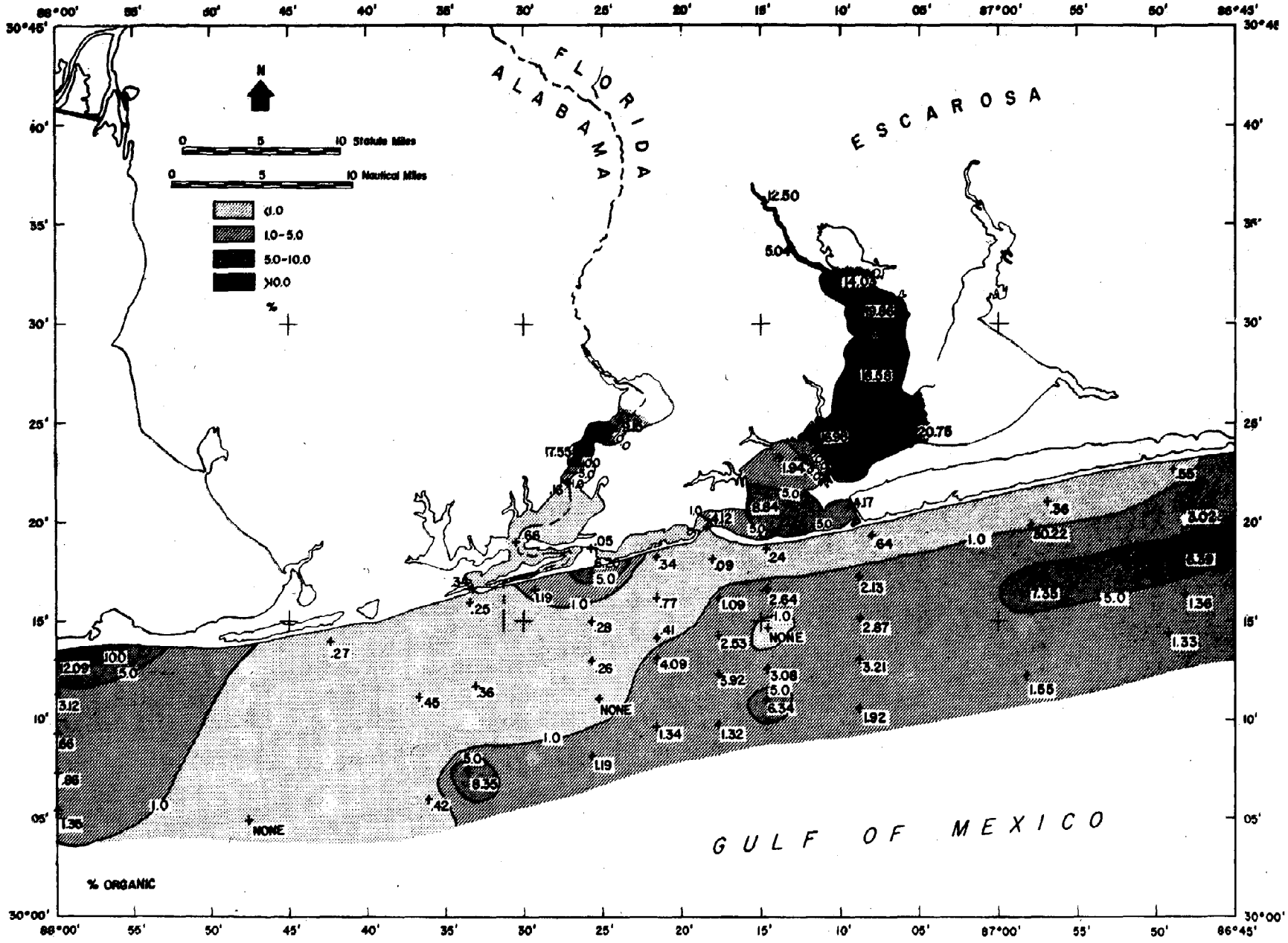


Figure 179 ESCAROSA I - Per Cent Organic

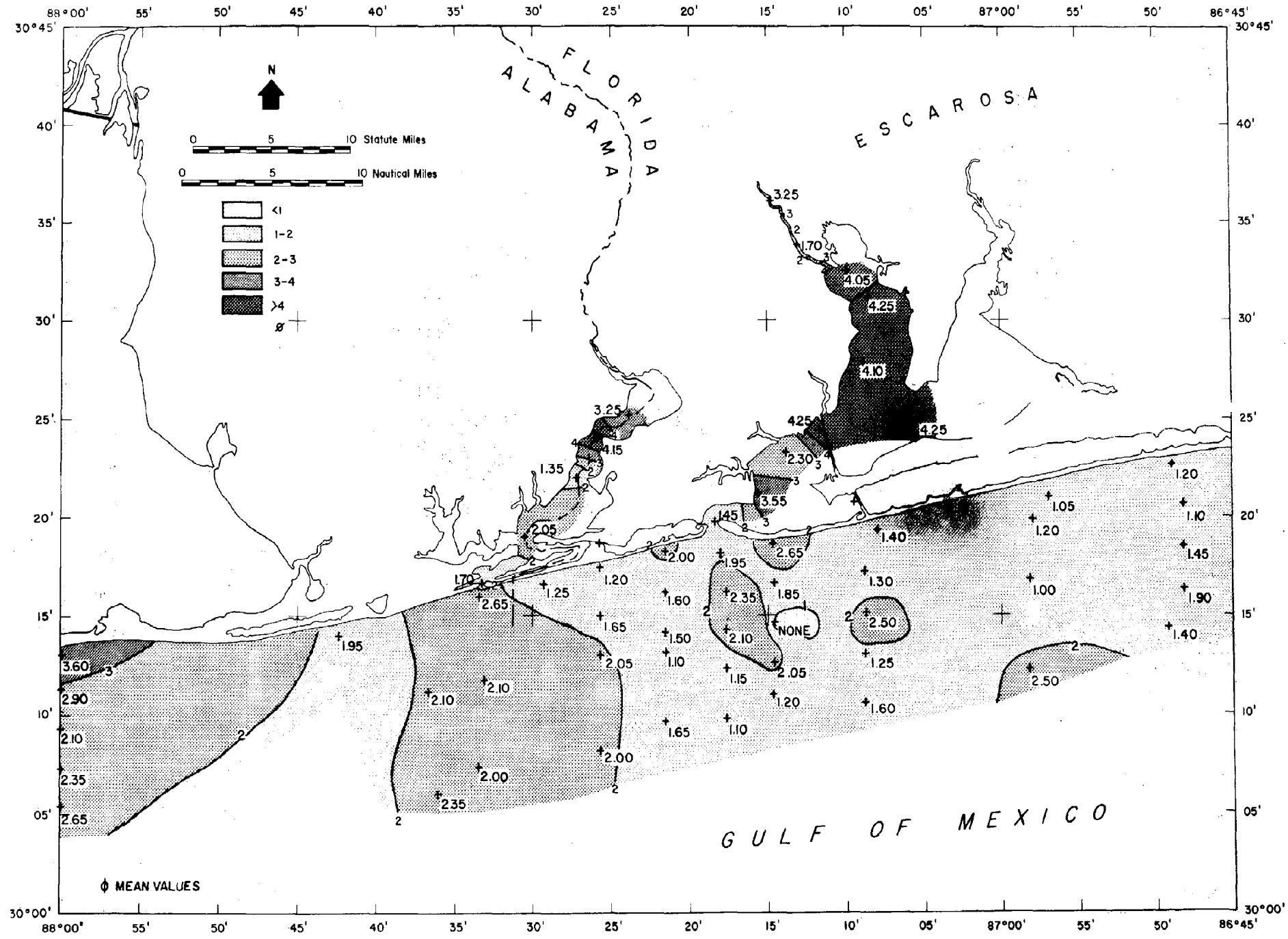


Figure 180 ESCAROSA I Phi Mean Sediment Size

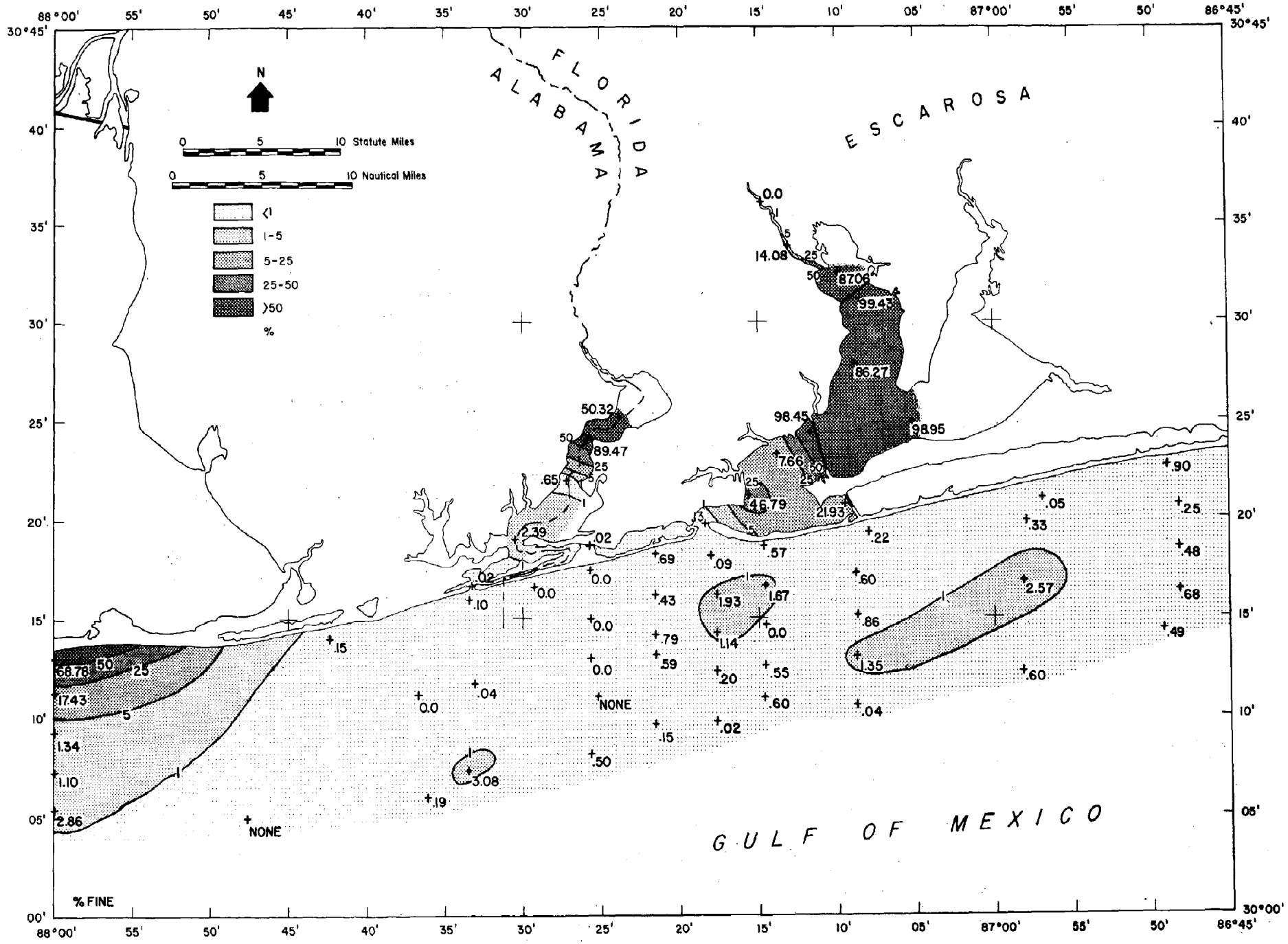


Figure 181 ESCAROSA I Per Cent Fine Material

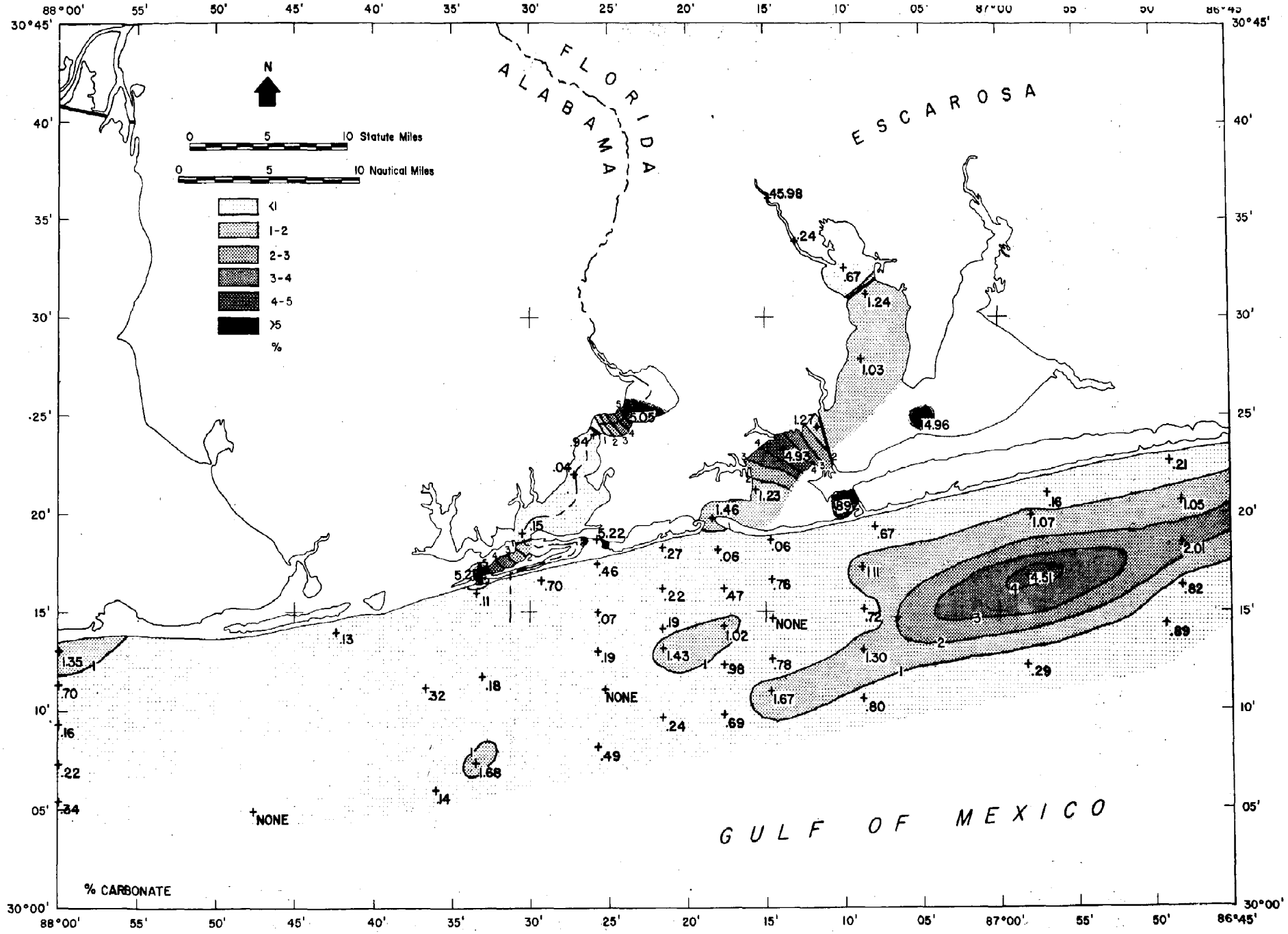


Figure 182 ESCAROSA I Per Cent Carbonate

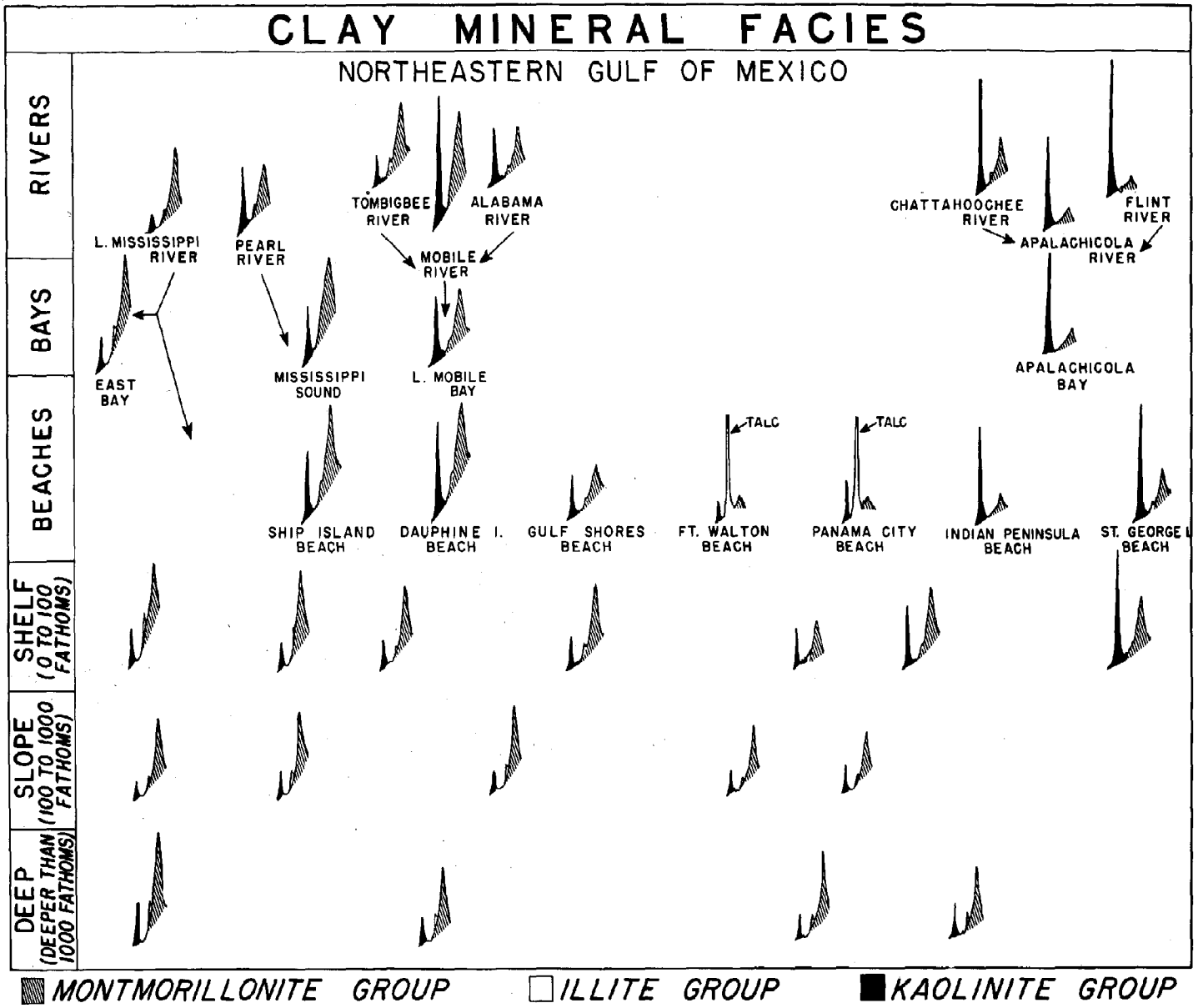


Figure 183 Schematic diagram of clay mineral distribution in the northeastern Gulf of Mexico (after Griffin, 1963). Shown are the 0° to 15° 2θ portions of X-ray diffraction patterns of <2 micron salt-free clay fractions. Note the easterly increase in height of the kaolinite peaks and the decrease in montmorillonite peaks.

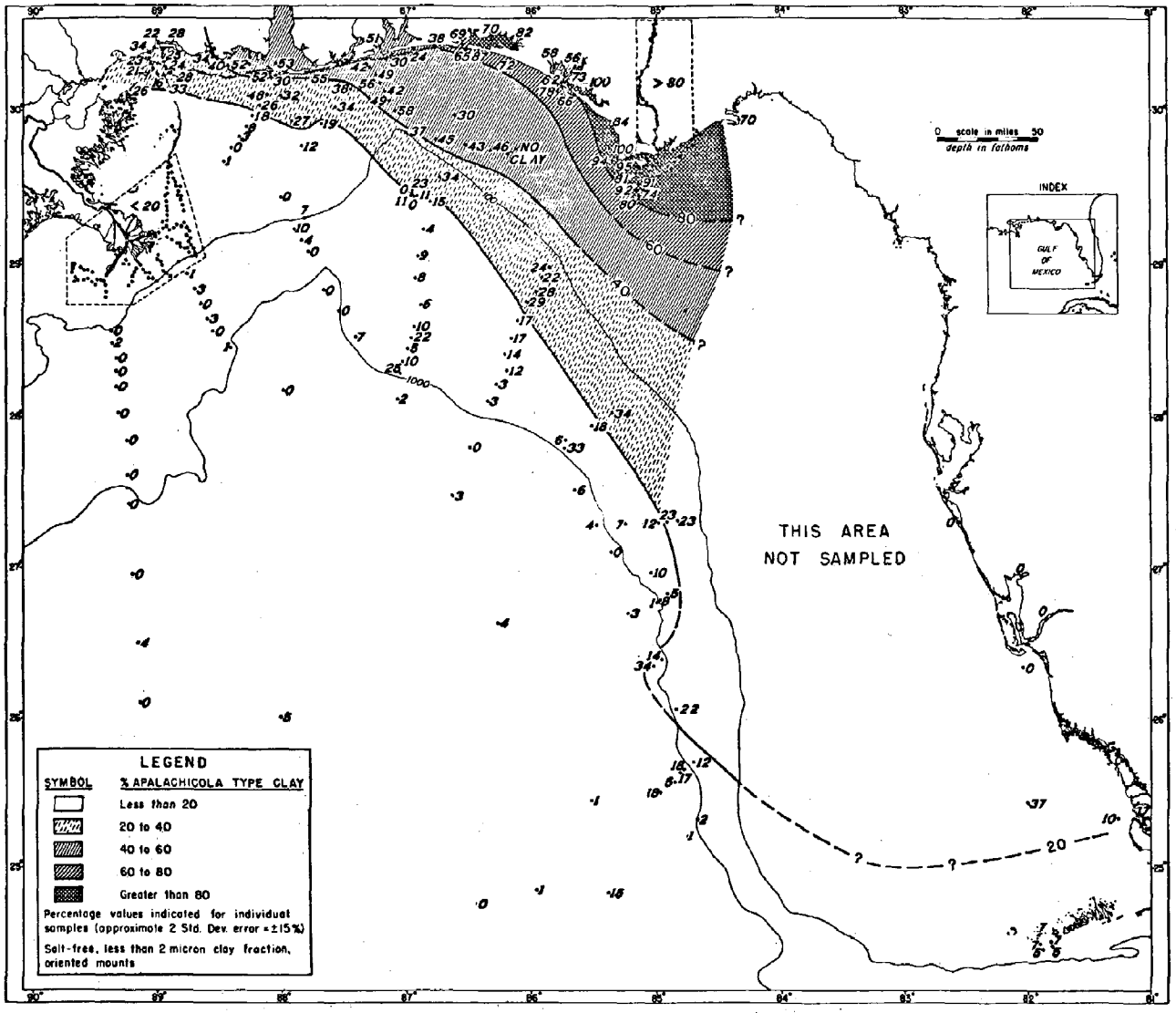


Fig. 184 – Clay Mineral Facies in Surface Sediments of the Northeastern Gulf of Mexico. Percentage Values of Apalachicola Type Were Obtained from the Working Curve on Figure

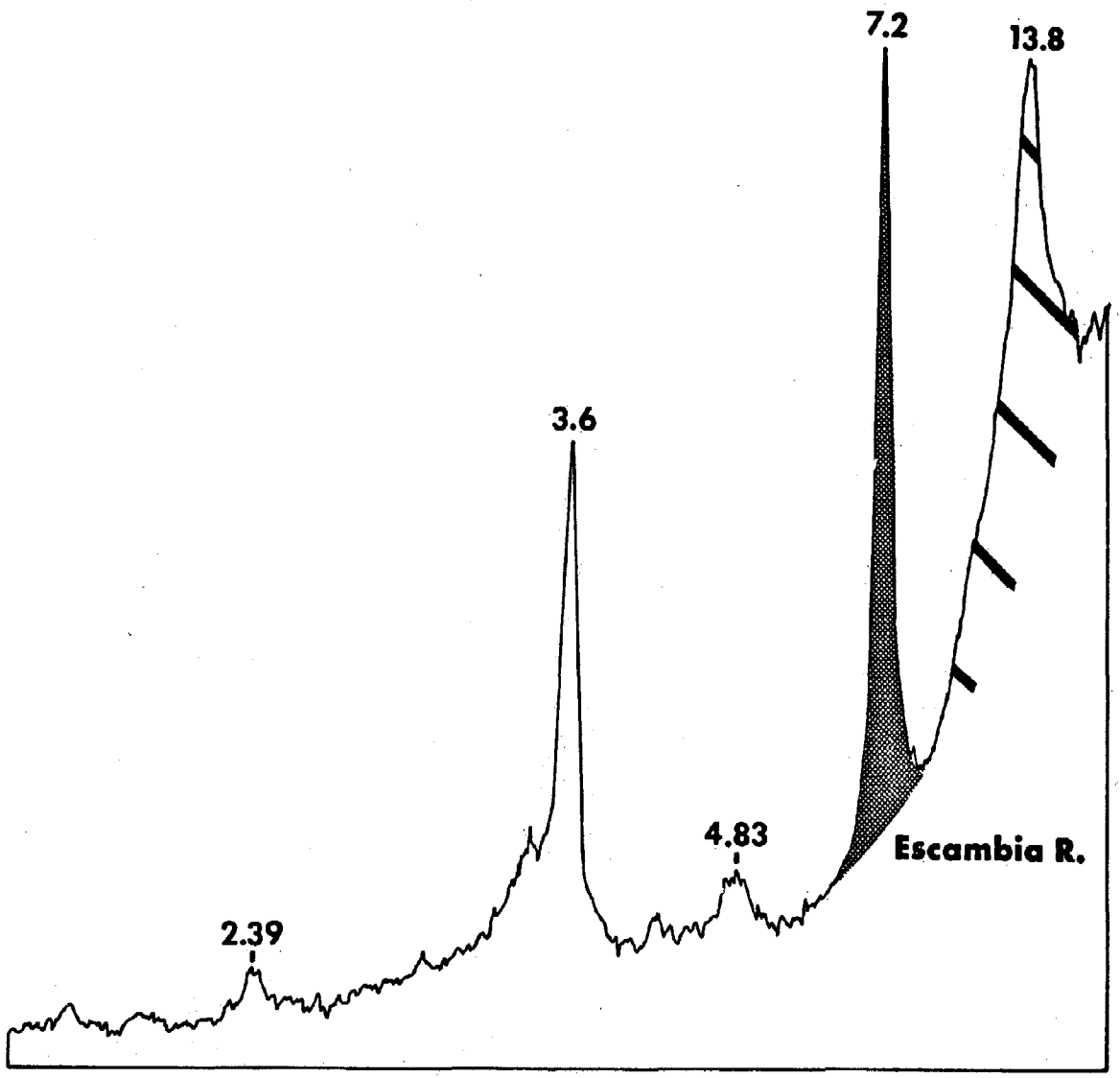


Figure 185 X-ray pattern of Escambia River clay from Station C-37 (.9). The 7.2A, 3.6A, and 2.39A peaks are from kaolinite; the 4.89A peak is from gibbsite, and the 13.8A peak is principally montmorillonite, possibly with minor vermiculite.

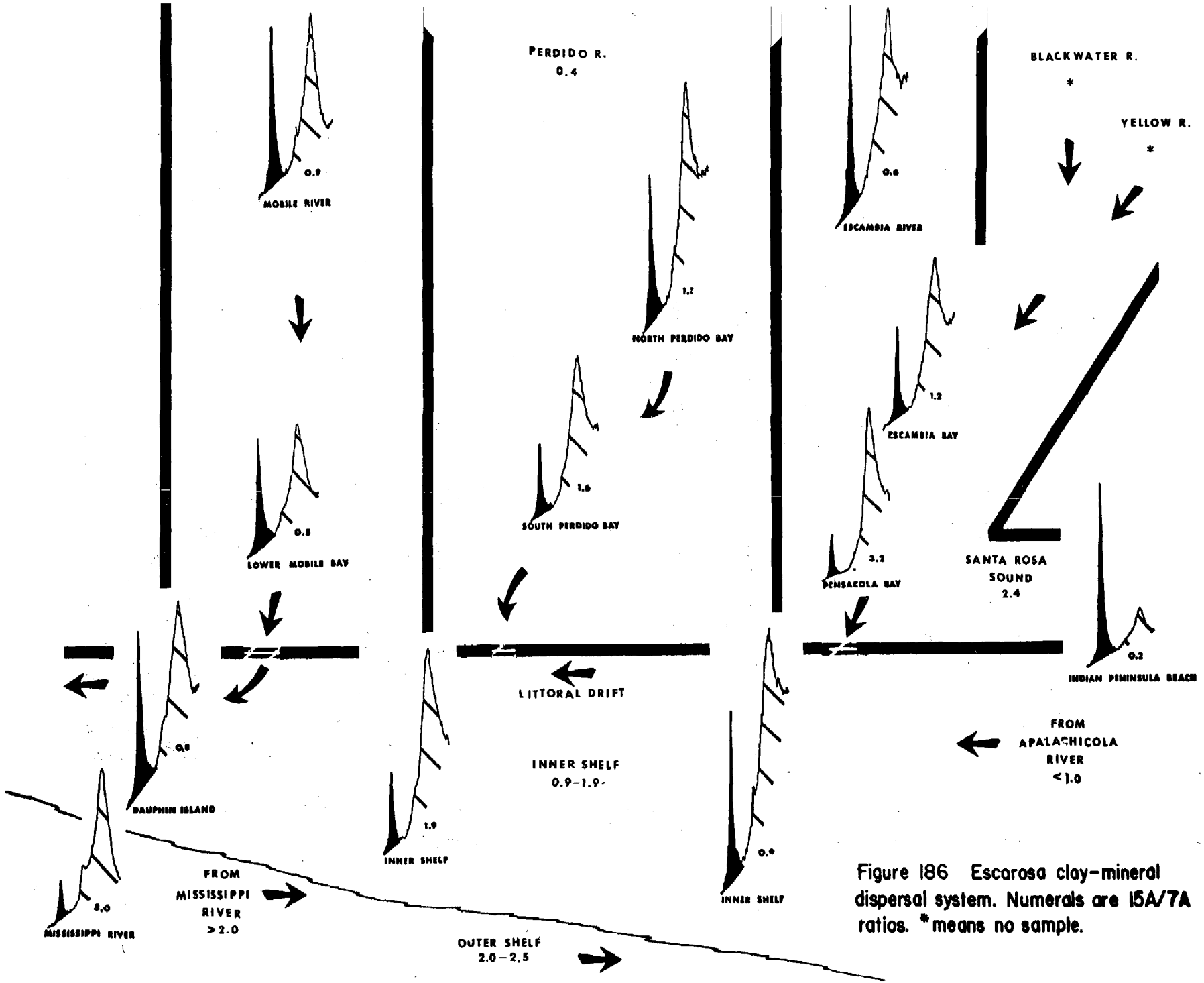


Figure 186 Escarosa clay-mineral dispersal system. Numerals are 15A/7A ratios. * means no sample.

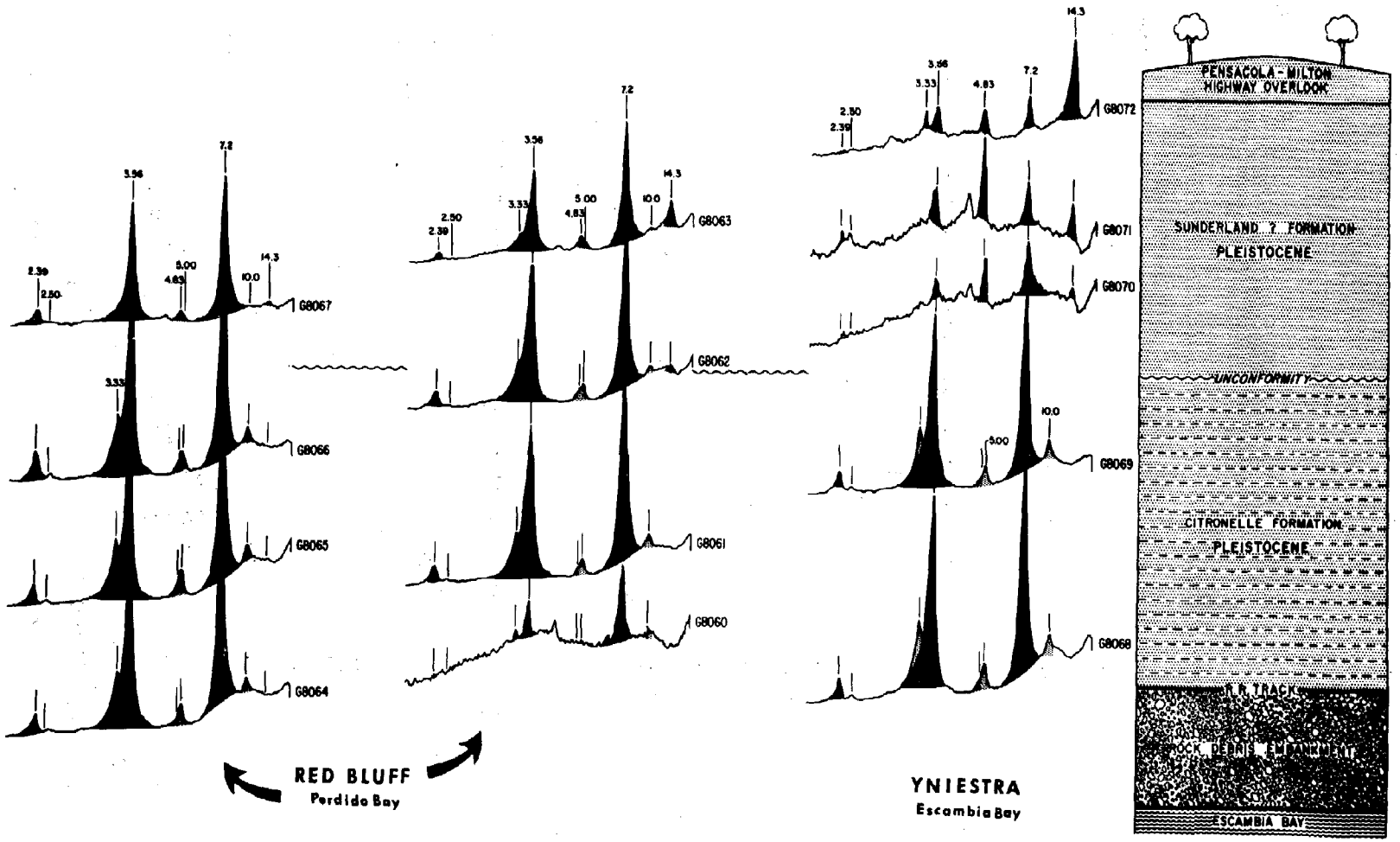


Figure 187 X-ray patterns of clays from bluff overlooking Perdido Bay and Escambia Bay. Peaks are labeled in angstrom units. Stratigraphic location of samples is indicated by column on the right.

A P P E N D I C E S

APPENDICES

APPENDIX I

Meteorology and Sea State Data

R/V BELLOWS

Station No.	Wind Direction Degrees	Wind Speed Kts	Wave Height Code WNO-1555	Wave Period Code WNO-3155	Present Weather WNO-4501
031	315	03	1	4	1
032	315	03	1	4	1
033	315	03	1	4	1
034	000	00	2	6	-
035	000	00	2	6	1
036	160	05	1	4	1
037	160	05	1	1	1
038	160	07	0	1	1
039	170	06	1	2	1
040	170	06	1	2	1
041	190	08	2	2	1
042	200	07	2	2	1
043	200	05	1	2	1
044	200	04	1	3	1
045	200	04	1	3	1
046	180	11	1	3	1
047	120	11	1	4	1
048	000	00	1	4	1
049	000	00	1	4	1
050	000	00	0	0	1
051	090	05	1	3	1
052	090	06	1	2	6
053	090	07	2	3	6
054	160	02	2	2	2
055	160	17	4	3	6
056	150	18	4	3	6
057	170	20	4	3	6
058	140	09	3	3	4
059	130	07	3	3	2
060	130	03	3	3	2

APPENDIX I contd.

R/V DAN BRAMAN

Station No.	Wind Direction Degrees	Wind Speed Kts	Wave Height Code WNO-1555	Wave Period Code WNO-3155	Present Weather WNO-4501
026	310	07	1	4	1
027	310	04	2	4	1
028	310	03	3	4	0
029	---	20	1	4	0
030	---	03	1	7	0
006	155	08	0	6	0
007	160	10	1	2	1
008	180	16	1	4	1
009	180	12	1	4	1
010	180	14	1	4	-
011	195	12	1	2	1
012	195	09	1	5	1
013	190	02	1	5	1
014	190	05	1	5	-
015	190	05	1	5	1
016	190	05	1	4	1
017	190	08	X	X	1
018	220	04	X	X	X
019	000	00	X	X	X
020	000	00	1	4	2
021	060	07	1	6	1
022	060	06	1	1	1
023	060	03	1	4	1
024	060	09	1	4	1
025	135	10	2	3	1
061	090	08	X	X	2
062	115	13	X	X	2
063	105	13	X	X	2
064	115	11	X	X	2
065	115	12	X	X	2

APPENDIX I contd.

R/V TURSIOPS

Station No.	Wind Direction Degrees	Wind Speed Kts	Wave Height Code WNO-1555	Wave Period Code WNO-3155	Present Weather WNO-4501
Section 1					
01	300	06	1	4	1
02	340	03	1	4	1
03	350	04	1	4	1
04	000	00	1	4	1
05	000	00	1	4	1
Section 2					
01	180	08	1	4	1
02	180	15	1	2	1
03	190	06	1	5	1
04	180	06	1	5	1
05	200	08	1	5	1
Section 3					
01	220	04	0	-	1
02	225	04	1	5	1
03	240	03	1	4	1
04	000	00	0	-	1
08	000	00	X	X	X
Section 4					
01	000	00	X	X	0
02	000	00	X	X	0
03	000	00	0	X	1
04	000	00	0	X	1
05	000	00	0	X	1
Section 5					
01	090	10	1	1	2
02	090	12	1	1	2
03	090	04	1	2	5
04	180	06	1	1	5
05	170	12	1	2	5

APPENDIX I contd.

Station No.	Wind Direction Degrees	Wind Speed Kts	Wave Height Code WNO-1555	Wave Period Code WNO-3155	Present Weather WNO-4501
Section 6					
01	190	12	2	3	5
02	185	06	2	2	3
03	180	01	1	4	5
04	190	02	1	3	2
05	185	01	1	3	2
Section 7					
01	350	06	1	1	2
02	020	04	1	1	2
03	090	10	2	2	1
04	090	10	2	2	1
05	110	12	2	2	1
Section 8					
01	090	08	1	3	1
02	140	08	1	3	1
03	140	10	-	-	1
04	140	12	2	4	1
05	140	10	2	4	2

APPENDIX II

Oxygen Saturation Values (Fox 1909)

Section No.	Station No.	Depth (Meters)	Percent of Oxygen Saturation
20	1	01	99.6
		05	90.4
	2	01	101.9
		09	71.9
	3	01	97.8
		06	83.8
		12	88.6
	4	01	92.5
		06	89.2
		15	86.9
	5	01	99.3
		10	92.6
19	1	01	100.6
		09	77.9
	2	01	106.1
		08	103.6
	3	01	106.4
		06	106.5
		12	85.5
	4	01	102.3
		06	120.2
		13	90.0
	5	01	102.0
		10	104.6
		19	104.1
18	1	01	100.5
		07	96.9
	2	No samples taken	
	3	01	92.9
		06	94.8
		12	101.5

APPENDIX II contd.

Section No.	Station No.	Depth (Meters)	Percent of Oxygen Saturation
	4	01	96.4
		06	106.5
		13	105.8
	5	01	104.6
		08	101.6
		15	102.8
17	1	01	113.6
		06	88.1
	2	01	105.1
		10	96.1
	3	01	101.4
		06	110.6
		13	93.4
	4	01	103.5
		08	105.8
		16	123.4
	5	01	105.0
		10	97.1
		21	94.2
16	1	01	96.8
		07	121.0
	2	01	110.9
		09	117.4
	3	01	105.0
		06	111.9
		13	108.5
	4	01	106.8
		07	107.3
		15	102.9
	5	01	109.8
		10	108.7
		21	106.5

APPENDIX II contd.

Section No.	Station No.	Depth (Meters)	Percent of Oxygen Saturation
15	1	01	111.2
		06	108.2
	2	01	112.6
		12	111.0
	3	01	110.8
		08	110.4
		18	109.2
	4	01	115.5
		11	119.7
		23	92.4
	5	01	131.0
		11	111.4
		22	104.9
14	1	01	120.0
	2	01	111.7
		10	99.2
	3	01	114.5
		08	108.9
		15	97.6
	4	01	106.0
		10	110.4
		21	148.3
	5	01	131.7
		13	100.8
		23	113.2
13	1	01	135.5
	2	01	110.5
		12	109.6
	3	01	114.9
		08	119.2
		15	96.7

APPENDIX II contd.

Section No.	Station No.	Depth (Meters)	Percent of Oxygen Saturation
	4	01	111.2
		09	110.3
		17	107.9
	5	01	131.2
		10	114.7
		19	99.0
1	1	01	104.5
		05	98.5
	2	01	101.2
		15	92.9
	3	01	115.5
		10	121.1
		21	93.0
	4	01	105.3
		10	109.9
		18	95.0
	5	01	109.6
		10	120.6
		22	97.7
12	1	01	111.8
		09	105.9
	2	01	129.6
		15	109.5
	3	01	115.0
		10	110.0
		19	99.2
	4	01	121.9
		11	105.9
		22	107.7
	5	01	103.9
		12	116.7
		24	96.8

APPENDIX II contd.

Section No.	Station No.	Depth (Meters)	Percent of Oxygen Saturation
11	1	01	117.7
		09	115.7
	2	01	104.6
		19	96.3
	3	01	105.5
		12	102.9
		23	96.9
	4	01	105.5
		13	105.1
		25	99.2
	5	01	104.9
		13	100.8
		25	99.2
10	1	01	107.7
		10	97.0
	2	01	98.0
		26	99.7
	3	01	101.8
		12	111.1
		24	100.5
	4	01	106.0
		12	107.4
		24	99.2
	5	01	118.3
		13	101.7
		24	104.5
		26	98.9
9	1	01	97.8
		11	93.2
	2	01	103.6
		18	93.8

APPENDIX II contd.

Section No.	Station No.	Depth (Meters)	Percent of Oxygen Saturation
	3	01	107.3
		10	107.3
		19	88.8
	4	01	99.1
		10	95.1
		20	89.8
	5	01	106.7
		15	105.3
		24	94.2
		R/V TURSIOPS TIME SERIES	
1	1	01	104.5
		05	98.5
	2	01	101.2
		15	92.9
	3	01	115.5
		10	121.1
		21	93.0
	4	01	105.3
		10	109.9
		18	95.0
	5	01	109.6
		10	120.6
		22	97.7
2	1	01	90.3
		11	94.5
	2	01	107.6
		14	85.4
	3	01	110.8
		05	106.8
		20	88.7

APPENDIX II contd.

Section No.	Station No.	Depth (Meters)	Percent of Oxygen Saturation
	4	01	106.0
		05	103.8
		18	104.3
	5	01	104.2
		05	102.9
		22	106.5
3	1	01	113.6
		05	95.3
	2	01	102.7
		15	88.7
	3	01	107.5
		06	99.5
		19	89.6
	4	01	105.0
		07	110.5
	5	01	106.6
		08	94.9
		21	94.0
4	1	01	100.6
		05	95.8
	2	01	104.0
		13	90.6
	3	01	99.5
		07	101.4
		20	88.5
	4	01	112.7
		07	101.4
	5	01	107.6
		07	97.3
		22	94.4
5	1	01	100.7
		05	94.9

APPENDIX II contd.

Section No.	Station No.	Depth (Meters)	Percent of Oxygen Saturation
	2	01	98.3
		13	77.3
	3	01	99.0
		08	94.5
		22	83.0
	4	01	97.4
		09	93.2
		17	89.9
	5	01	107.5
		08	103.8
		21	97.0
6	1	01	96.0
		05	95.6
	2	01	101.0
		15	87.0
	3	01	105.0
		07	104.4
		20	90.0
	4	01	102.8
		09	100.0
		18	88.3
	5	01	103.6
		08	100.3
		22	91.0
7	1	01	100.2
		04	91.9
	2	01	96.2
		14	88.5
	3	01	98.7
		07	99.4
		19	85.5

APPENDIX II contd.

Section No.	Station No.	Depth (Meters)	Percent of Oxygen Saturation
	4	01	100.5
		10	94.8
		16	87.5
	5	01	105.9
		11	97.5
		21	86.5
8	1	01	98.7
		05	91.5
	2	01	102.0
		15	92.4
	3	01	97.6
		06	93.6
		18	85.9
	4	01	98.5
		08	98.2
		18	88.7
	5	01	100.8
		10	102.2
		22	87.8

APPENDIX III

Sediment Size Parameters

Sample Number	Mean	Standard Deviation	Skewness	Kurtosis
71261	1.947	0.536	-0.057	0.242
71262	2.353	0.722	-0.215	2.041
71263	2.096	0.720	-0.483	4.158
71264	1.126	0.734	-0.258	2.075
71265	1.071	0.750	-0.274	0.573
71256	2.668	0.639	-0.393	1.025
71257	1.852	1.051	-0.515	1.797
71258	0.237	1.418	-0.084	-0.992
71259	2.074	0.647	-0.354	2.713
712510	1.216	0.921	-0.365	2.043
712511	1.385	0.624	-0.018	0.850
712512	1.320	0.725	-0.099	1.995
712513	2.482	0.608	-0.247	2.165
712514	1.250	0.892	-0.120	2.561
712515	1.612	0.710	-0.398	1.589
712516	1.028	0.706	-0.331	3.076
712517	1.209	0.915	-0.564	2.568
712518	1.082	1.369	-0.055	-0.033
712520	2.506	0.586	-0.402	2.723
712521	1.189	0.846	-0.005	2.282
712522	1.089	0.756	-0.181	1.642
712523	1.464	0.872	-0.499	2.740
712524	1.919	0.662	-0.307	3.893
712525	1.390	0.747	-0.195	2.444
712526	1.987	0.617	-0.031	1.878
712527	1.612	0.636	0.213	2.104
712528	1.513	0.647	0.142	3.384
712529	1.110	0.880	-0.445	2.745
712530	1.632	0.561	-0.006	0.944
712731	1.178	0.651	-0.180	0.602

APPENDIX III contd.

Sample Number	Mean	Standard Deviation	Skewness	Kurtosis
712732	1.646	0.475	-0.270	3.078
712733	2.039	0.569	-0.366	1.475
712735	2.011	0.641	-0.421	4.046
712736	1.269	0.571	-0.069	2.212
712741	2.626	0.491	-0.882	8.613
712743	2.115	0.608	-0.376	1.668
712745	2.010	0.799	0.010	2.684
712748	2.083	0.583	-0.431	1.063
712750	2.338	0.506	-0.360	4.013
712751	1.965	0.557	-0.079	1.347
712561	3.605	1.017	-0.579	-0.197
712562	2.884	0.883	-0.269	2.405
712563	2.094	0.615	0.101	3.584
712564	2.345	0.526	0.059	2.986
712565	2.671	0.643	-0.177	2.724
PBAYC25	1.336	0.812	0.203	0.875
PBAYC26	2.033	0.838	0.026	1.459
PBAYC27	1.710	0.497	-0.040	3.782
PBAYC28	1.403	0.511	-0.128	0.334
PBAYC29	4.145	0.307	-----	4.540
PBAYC30	3.227	1.279	-0.478	-0.340
EBAYC37	3.250	0.003	-----	-----
EBAYC38	1.687	1.246	0.315	0.981
EBAYC39	4.056	0.503	-----	2.853
EBAYC40	4.242	0.112	-----	-----
EBAYC42	4.113	0.344	-----	2.378
NBAYC43	4.240	0.101	-----	-----
NBAYC44	4.235	0.123	-----	-----
NBAYC45	2.282	0.778	0.195	3.181
RBAYC46	2.061	1.507	-0.066	-0.040
NBAYC47	3.525	0.857	-0.820	5.797
RBAYC48	1.446	0.794	-0.910	4.949

APPENDIX IV

X-Ray Data

X-ray diffraction data for ESCAROSA samples. Salt-free, <2 micron clay fractions. Copper Kα radiation at 34 Kv, 20 ma, 2 second time-constant. Sedimented slides.

Explanation of terms and units: UNT.CPS = counts per second for full scale deflection of recorder on untreated samples; h 15A, h 7A, etc. = height of peak indicated, in mm, at the indicated CPS rate, peak locations are at approximately the locations indicated, in Angstrom units; 15/7 = height of approximately 15A peak divided by height of approximately 7A peak; 17/7 = height of peak at approximately 17A after ethylene glycol imbibition treatment divided by height of peak at approxiamtely 7A after ethylene glycol treatment; h 4.83 @ 500 CPS - height in mm of 4.83A gibbsite peaks on untreated patterns of salt-free clay fractions; E.G. CPS = counts per second full scale deflection used for patterns following ethylene glycol treatment; posit. E.G. peak = position of montmorillonite (+ vermiculite) 001 peak in Angstrom units after ethylene glycol treatment; UNT = clay untreated except for distilled water washing followed by centrifugation to extract <2 micron clay fractions from the bulk samples; * = insufficient clay for analysis or sample otherwise unusable.

APPENDIX IV contd.

Station No.	UNT. CPS	h 15A	h 7A	15/7	h 4.83 @ 500 CPS	E.G. CPS	h 17	h 7	17/7	Posit. E.G.P.
I-22	500	187	162	1.15	21					
	1000	80	85	0.94		1000	71	78	0.91	16.3
E-4	1000	107	67	1.60	18	1000	109	67	1.63	16.5
L-42	*					*				*
M-18	*					*				*
D-3	1000	74	64	1.16	22	1000	58	61	0.95	16.6
B-11	500	148	137	1.08	18	1000	70	67	1.04	16.5
.9	500	116	189	0.61	17	1000	50	92	0.54	17.0
.37	500	92	106	0.87	12					
	1000	46	57	0.81	6	1000	45	45	1.00	17.0
C-9	1000	95	84	1.13	14	1000	105	78	1.35	17.0
D-2	1000	105	86	1.22	18	1000	83	76	1.09	17.0
F-14	1000	101	75	1.35	14	1000	73	59	1.24	17.0
D-45	1000	144	87	1.66	24	1000	120	73	1.64	16.8
J-8	2000	87	39	2.23	20	2000	86	33	2.61	17.0
J-18	1000	186	79	2.35	16	2000	105	32	3.28	17.0
G-53	2000	97	41	2.37	24	2000	97	41	2.37	17.0
L-19	2000	122	38	3.21	20	2000	129	34	3.79	16.9
N-14	*					*				*
SUSIO 7126										
01	*					*				*
02	100	135	149	0.91	0	200				*
03	200	119	83	1.45	2	200				*
04	100	46	42	1.10	2	100				17.0
05	100	88	57	1.54	2	100				*
SUSIO 7127										
31	*					*				*
32	*					*				*
33	*					*				*
34	*					*				*
35	100	125	93	1.34	4					
		125	101	1.24		*				*

APPENDIX IV contd.

Station No.	UNT. CPS	h 15A	h 7A	15/7	h 4.83 @ 500 CPS	E.G. CPS	h 17	h 7	17/7	Posit. E.G.P.
36	*					*				*
41	*					*				*
43	*					*				*
45	200	185	142	1.30	8	500	96	63	1.52	16.5
48	*					*				*
50	200	156	136	1.15	5					
	200	154	136	1.13		200	64	82	0.78	16.2
51	500	111	90	1.23	15	1000	95	78	1.22	16.4
60	100	59	43	1.37	0	*				*
SUSIO 7125										
61	1000	134	69	1.94	6	1000	149	57	2.61	17.0
62	1000	160	73	2.19	6	500	134	72	1.86	16.6
63	1000	108	67	1.61	7	1000	85	45	1.89	17.0
64	500	129	52	2.48	11	1000	77	23	3.35	17.0
						1000	66	23	2.87	17.0
65	1000	96	44	2.18	12	1000	77	26	2.96	17.0
						1000	97	32	3.03	17.0
06	500	148	158	0.94	15	1000	38	65	0.61	17.0
07	500	59	50	1.18	7	500	40	47	0.85	17.0
08	*					*				*
09						500	41	28	1.46	17.0
	500	54	39	1.38	7	500	47	28	1.68	16.9
10	500	43	35	1.23	8?	200	100	65	1.54	17.0
11	500	13	17	0.87?	6?	*				*
12	500	55	44	1.25	5?	500	47	42	1.12	16.9
13	500	45	48	0.94	7	500	36	35	1.03	17.5
14	500	35	22	1.59	7	500	36?	23	1.57?	*
15	500	51	39	1.31	7	500	30?	37	0.81?	*
16	200	19	30	0.6 ?	20??	*				*
17	500	14	15	0.93	5	*				*
18	500	45	41	1.10	6	500	35	37	0.95	17.0
20	500	52	31	1.67	7					
	500	45	38	1.18	8	500	38?	34	1.12?	*

APPENDIX IV contd.

Station No.	UNT. CPS	h 15A	h 7A	15/7	h 4.83 @ 500 CPS	E.G. CPS	h 17	h 7	17/7	Posit. E.G.P.
21	500	25	24	1.04	6	500	36?	27	1.33?	*
22	500	12	18	0.67	6	500	18?	17	1.06?	16.0?
23	500	21	16	1.31	4	500	21	16	1.31	17.0
24	500	28	25	1.12	6	500	22	23	0.96	*
25	500	22	25	0.88	4	500	10?	25	0.40?	*
26	500	27	49	0.55	10	500	30?	41	0.73?	16.0
27	*					*				*
28	500	76	45	1.69	8	500	41	91	0.45	18.0
29	500	64	37	1.73	8					
	1000	36	20	1.80		500	72	37	1.95	17.0
30	500	32	37	0.86	9	500	33	39	0.85	17.0

APPENDIX V

The observed concentrations of selected trace metals of the territorial waters of Florida offshore from ESCAROSA.

Section No.	Station No.	Depth (Meters)	Trace Metals (ppb) Cd	Pb	Cu	Cr	Zn	Mn
20	1	01	0.26	0.49	1.84	0.50	7.83	12.71
		06	0.33	1.31	1.84	0.39	9.27	5.59
	2	01	0.26	0.95	2.12	0.33	12.75	5.78
		10	0.26	1.28	1.84	0.73	15.62	9.34
	3	01	0.30	1.26	1.28	0.28	8.91	0.8
		06	0.33	0.76	1.56	0.39	6.01	7.32
		13	0.60	0.82	1.56	0.84	5.98	14.45
	4	01	0.25	0.23	1.07	1.06	4.50	1.24
		06	0.29	1.35	1.07	0.86	5.16	2.12
		16	0.14	0.437	0.64	0.70	5.04	6.16
19	1	01	0.04	1.11	1.26	0.81	4.17	1.13
		09	0.03	0.41	1.04	0.49	3.62	5.81
	2	01	0.15	0.25	0.95	0.68	4.07	0.89
		08	0.04	0.46	1.58		12.90	27.11
	3	01	0.09	0.41	0.97	0.43	9.77	6.05
		12	0.09	0.23	1.65	0.61	4.32	4.97
	4	01	0.04	0.12	0.90	0.74	4.07	1.01
		13	0.08	0.16	0.75	0.49	4.52	1.73
	5	01	0.05	0.12	3.97	0.61	3.77	0.41
		19	0.01	0.08	0.99	0.77	5.00	3.42
						0.75	4.77	3.41
18	1	01	0.04	0.43	1.41	0.53	4.09	2.70
		07	0.03	0.26	1.58	0.68	3.69	2.80
	3	01	0.43	0.27	1.04	0.49	7.30	4.52
						0.38		

APPENDIX V contd.

Section No.	Station No.	Depth (Meters)	Trace Metals (ppb) Cd	Pb	Cu	Cr	Zn	Mn
		06	0.09	0.30	1.15	0.98	9.25	1.51
		12	0.07	0.31	1.22	1.49	11.70	0.41
						1.55		
	4	01	0.08	0.18	1.44	0.42	4.39	2.20
		13	0.07	0.23	1.00	0.67	3.87	4.20
	5	01	0.09	0.49	1.17	0.72	3.75	3.82
		15	0.14	0.53	1.24	0.81	3.72	3.41
17	1	01	0.04	0.63	2.00	2.00	9.00	5.00
		06	0.03	0.37	1.60	1.98	5.48	1.27
	2	01	0.03	0.58	2.00	0.52	4.25	1.26
		10	0.05	0.47	6.00	0.67	5.62	1.01
	3	01	0.25	0.68	3.00	0.41	5.40	2.00
		13	0.07	0.81	13.80	8.00	9.60	0.80
	4	01	0.24	0.53	1.52	0.78	5.02	1.25
		16	0.07	0.78	1.45	1.02	15.53	6.25
	5	01	0.03	0.36	2.92	0.79	3.52	0.67
		21	0.05	0.71	1.42	1.01	3.21	2.02
16	1	01	0.06	0.89	1.75	1.29	4.62	10.91
		07	0.02	0.47	1.33	1.13	5.82	1.61
	2	01	0.03	0.59	1.10	0.81	4.37	0.77
		09	0.04	0.61	1.49	1.13	5.52	0.77
	3	01	0.09	0.88	1.58	0.81	5.62	6.53
		06	0.05	1.08	1.80	0.48	12.70	2.09
		13	0.05	1.27	1.68	1.94	17.90	2.21
	4	01	0.07	0.88	2.08	0.81	9.12	0.95
		15	0.07	1.01	1.75	0.65	17.10	1.37
	5	01	0.03	0.41	1.07	0.81	3.82	0.41
		21	0.05	1.09	1.56	1.77	4.87	1.61
15	1	01	0.03	0.52	1.04	0.70	3.90	2.16
		06	0.21	0.37	0.70	0.86	5.36	1.70
					0.73	0.50	2.52	4.40

APPENDIX V contd.

Section No.	Station No.	Depth (Meters)	Trace Metals (ppb) Cd	Pb	Cu	Cr	Zn	Mn
	2	01	0.04	0.49	2.27	0.96	3.67	1.98
		12	0.08	0.20	2.25	9.24	4.38	2.48
	3	01	0.37	0.19	0.75	0.86	2.82	3.20
		08	0.16	0.84	1.21	0.96	10.38	1.84
		18	1.46	0.18	1.93	0.65	4.32	2.48
	4	01	0.78	0.87	1.93	2.19	7.68	1.40
		11	0.43	0.33	1.29	0.65	4.50	1.36
		23	0.04	1.00	0.82	0.96	3.06	2.32
	5	01	1.00	0.45	1.36	0.65	5.40	1.20
		11	0.05	0.47	1.41	0.42	3.74	0.68
		22	0.04	0.63	1.22	1.72	4.52	1.13
14	1	01	1.66	0.28	0.93	0.84	4.33	0.86
		06	0.20	0.42	1.28	2.64	3.78	0.67
	2	01	0.20	0.48	1.07	0.61	3.49	0.58
		10	0.13	0.16	1.66	0.28	2.26	0.67
	3	01	0.11	0.48	0.75	0.60	3.24	2.16
		08	0.20	0.64	0.73	0.67	7.59	0.58
		15	0.03	0.48	1.90 1.72	6.01	5.18	1.35
	4	01	0.13	0.51	0.93	0.76	4.68	2.28
		10	0.00	0.57	2.05	0.39	4.33	0.38
		21	0.26	0.35	1.70	0.00	4.68	1.92
	5	01	0.32	0.26	1.07	0.70	5.04	1.20
		13	0.33	1.55	2.81	0.33	9.39	0.58
		23	0.10	0.53	1.70	0.73	3.49	0.86
13	1	01	0.06	0.43	0.00	0.84	3.73	1.73
		08	0.20	0.56	1.07	0.50	27.81	2.02
	2	01	0.13	0.33	0.73	0.73	3.25	1.35
		12	0.00	0.73	0.00	0.73	13.99	1.92
	3	01	0.20	0.98	2.39	0.73	2.77	4.10
		08	0.06	0.53	0.73	0.61	2.53	0.58
		16	0.20	0.35	1.28	0.84	23.02	2.50

APPENDIX V contd.

Section No.	Station No.	Depth (Meters)	Trace Metals (ppb) Cd	Pb	Cu	Cr	Zn	Mn
	4	01	0.20	0.30	0.86	0.73	1.80	1.92
		09	0.13	0.38	2.34	0.75	2.47	0.47
					1.98	0.50	2.22	
		18	0.60	0.60	1.42	0.64	22.75	1.94
	5	01	0.00	0.66	5.72	1.06	3.95	0.96
		10	0.00	0.72	0.86	0.81	3.33	2.00
					0.86	0.73	2.65	0.38
		17	0.06	0.78	1.50	0.76	9.03	2.00
					1.49	0.73	8.91	1.15
1	1	01	0.08	0.36	2.20	1.49	15.92	1.00
		05	0.08	1.14	1.58	2.10	7.52	1.49
	2	01	0.06	0.84	1.26	0.97	5.22	1.73
		15	0.05	0.85	1.16	0.32	5.97	1.31
	3	01	0.03	0.78	2.18	0.48	10.90	2.33
		10	0.06	0.73	1.41	0.81	6.37	0.95
		21	0.07	0.38	2.55	0.61	9.81	0.90
	4	01	0.03	0.30	1.47	0.61	14.13	1.20
			0.02	0.33		0.55		
		10	0.03	0.24	0.79	0.61	12.76	2.00
		18	0.05	0.48	0.83	1.06	4.65	3.00
			0.06	0.38	2.29	0.68	13.28	1.00
	5	01	0.04	0.30	1.85	2.24	12.65	2.00
		10	0.09	2.70	1.60	15.25	26.50	2.30
		22	2.80	7.70	3.60	2.00	7.50	8.90
12	1	01	0.16	0.09	0.82	1.37	3.18	1.36
		10	0.26	0.58	0.61	1.16	6.24	3.44
	2	01	0.18	0.14	0.71	0.65	3.78	1.24
		16	0.15	0.14	0.54	1.06	3.18	2.56
	3	01	0.13	0.26	1.32	0.76	8.34	2.00
		10	0.13	0.24	0.64	1.29	3.52	1.12
		20	0.21	0.22	1.21	0.65	5.04	1.44

APPENDIX V contd.

Section No.	Station No.	Depth (Meters)	Trace Metals (ppb) Cd	Pb	Cu	Cr	Zn	Mn
	4	01	0.21	0.18	0.79	0.76	3.90	1.36
							4.44	1.36
		11	0.20	0.31	0.85	0.87	4.75	1.36
		22	0.18	0.37	1.00	0.91	5.10	1.36
	5	01	0.06	0.27	1.41	0.92	7.04	1.67
		12	0.01	0.26	0.76	2.12	3.18	1.72
		25	0.06	0.14	0.73	0.99	2.83	2.01
11	1	01	0.19	0.10	3.62	23.55	23.28	4.20
				0.63				
		09	0.08	0.66	6.60	7.00	400.00	4.00
	2	01	0.06	0.75	3.05	1.18	8.86	1.90
		20	0.10	0.73	3.25	0.42	9.60	2.80
						0.44		
	3	01	0.07	1.03	2.03	0.50	19.79	5.80
			0.07		1.90	0.50	10.02	
		12	0.08	0.61	2.05	0.55	16.34	2.20
		24	0.06	0.45	2.12	0.68	18.55	0.70
	4	01	0.03	0.30	1.43	0.86	12.44	1.60
		12	0.04	0.41	1.56	1.13	12.33	2.00
		26	0.05	0.47	3.00	0.40	8.00	7.00
	5	01	0.04	0.33	1.90	1.00	6.34	2.30
		13	0.03	0.33	1.90	0.74	13.60	0.80
		26	0.07	0.51	2.45	0.49	16.76	2.00
10	1	01	0.03	0.12	1.41	0.67	4.98	2.00
		11	0.04	0.17	0.90	0.97	6.78	4.20
	2	01	0.04	0.12	1.07	0.99	4.13	1.80
		27	0.04	0.06	1.07	1.92	4.43	2.00
			0.42	0.03				
	3	01	0.03	0.18	0.87	0.37	3.21	2.27
		12	0.03	0.10	1.21	0.63	3.65	1.60
		25	0.04	0.14	1.24	0.38	3.85	2.10

APPENDIX V contd.

Section No.	Station No.	Depth (Meters)	Trace Metals (ppb) Cd	Pb	Cu	Cr	Zn	Mn
	4	01	0.09	0.07	0.90	0.94	7.43	4.16
		12	0.03	0.16	0.87	0.92	7.35	1.60
		25	0.03	0.21	0.98	0.93	7.25	0.97
	5	01	0.04	0.34	1.31	0.67	5.63	1.80
		13	0.21	0.40	1.25	0.80	3.00	0.80
		27	0.11	1.20	1.59	2.60	18.00	0.91
9	1	01	0.16	0.50	0.70	0.20	0.16	1.00
		12	0.21	0.55	1.65	1.16	19.00	0.90
	2	01	0.06	0.25	1.25	0.32	8.50	0.32
		19	0.04	3.25	2.15	0.32	36.50	1.00
			0.09		1.49	0.28		1.10
	3	01	0.75	0.24	1.80	0.30	12.50	0.68
			0.71	0.60	3.20	0.30	8.00	0.40
		10	0.38	1.70	3.63	2.50	32.50	0.63
		20	0.13	4.25	1.75	0.38	25.50	1.10
	4	01	0.11	0.80	5.15	0.30	36.50	0.70
			0.20	1.03	1.36	1.01	5.76	2.40
		10	0.50	2.40	1.00	0.38	4.00	1.40
		21	0.35	0.60	1.80	58.50	9.00	1.90
	5	01	0.32	0.38	2.25	0.55	3.24	1.44
		15	0.55	1.23	2.29	0.76	4.26	1.44
		25	0.41	0.56	1.50	0.60	3.90	1.36
			R/V TURSIOPS TIME SERIES					
1	1	01	0.08	0.36	2.20	1.49	15.92	1.00
		05	0.08	1.14	1.58	2.10	7.52	1.49
	2	01	0.06	0.84	1.26	0.97	5.22	1.73
		15	0.05	0.85	1.16	0.32	5.97	1.31
	3	01	0.03	0.78	2.18	0.48	10.90	2.33
		10	0.06	0.73	1.41	0.81	6.37	0.95
		21	0.07	0.38	2.55	0.61	9.81	0.90

APPENDIX V contd.

Section No.	Station No.	Depth (Meters)	Trace Metals (ppb) Cd	Pb	Cu	Cr	Zn	Mn
	4	01	0.03	0.30		0.61		
			0.02	0.33	1.47	0.55	14.13	1.20
		10	0.03	0.24	0.79	0.61	12.76	2.00
		18	0.05	0.48	0.83	1.06	4.65	3.00
			0.06	0.33	2.29	0.68	13.28	1.00
	5	01	0.04	0.30	1.85	2.24	12.65	2.00
		10	0.09	1.70	1.60	15.25	26.50	2.30
		22	2.80	7.70	3.60	2.00	7.50	8.90
2	1	01	0.79	1.10	1.00	0.50	70.00	6.35
		11	1.95	2.50	10.40	93.00	29.50	8.95
	2	01	0.09	1.45	7.20	0.36	25.00	4.15
		14	2.20	0.85	0.55	0.50	24.00	2.80
	3	01	0.75	1.40	11.10	0.40	24.50	1.80
		20	1.90	0.90	9.10	0.50	25.00	1.45
	4	01	0.85	2.15	0.48	0.40	32.00	0.60
		18	0.09	1.40	1.40	0.41	4.50	1.15
	5	01	0.73	3.30	0.55	15.25	6.50	1.80
		22	0.16	1.45	24.60	13.10	320.0	13.60
3	1	01	0.23	5.60	8.10	0.50	26.50	3.25
		05	0.07	0.56	1.52	0.81	8.34	3.75
	2	01	0.07	0.67	1.69	0.56	5.60	2.20
		15	0.02	0.92	1.27	1.45	4.44	1.73
	3	01	0.09	0.37	1.43	0.75	5.39	4.60
		19	0.09	0.43	1.09	0.50	7.18	2.30
	4	01	0.18	0.80	1.22	0.61	8.86	4.80
		17	0.03	0.36	3.06	0.56	14.23	2.50
	5	01	0.14	0.88	1.36	0.56	6.44	2.50
		21	0.15	2.55	10.1	0.40	25.00	0.80
4	1	01	0.09	0.60	8.50	0.41	25.00	1.80
		05	0.10	0.09	1.73	0.94	6.86	2.60

APPENDIX V contd.

Section No.	Station No.	Depth (Meters)	Trace Metals (ppb) Cd	Pb	Cu	Cr	Zn	Mn
	2	01	0.14	0.06	0.96	0.61	6.02	2.80
		13	0.07	0.77	1.82	0.94	5.71	3.30
	3	01	0.07	0.08	1.00	1.06	7.92	2.80
		07	0.06	0.05	1.13	0.69	7.60	1.80
		20	0.30	0.08	1.22	1.24	12.23	2.50
	4	01	0.04	0.78	0.83	0.56	3.60	3.70
		07	0.22	2.00	8.10	0.50	5.22	9.00
		18	0.15	0.77	1.34	0.81	8.44	1.80
	5	01	0.35	0.14	1.86	4.81	7.18	4.40
		07	0.06	0.15	1.13	0.37	13.18	1.80
		22	0.08	0.03	0.66	ND	3.60	1.80
5	1	01	0.26	0.33	6.00	3.00	88.00	0.80
		15	0.10	0.59	13.00	0.40	9.20	0.80
	2	01	0.10	0.64	10.60	0.40	30.00	0.60
		13	0.05	0.58	9.20	2.00	200.00	12.00
	3	01	0.12	0.40	0.48	10.00	152.00	6.00
		20	0.11	0.53	1.60	2.00	135.00	3.52
	4	01	0.15	0.83	4.00	7.04	130.00	2.80
		17	0.05	0.39	22.00	6.48	166.50	0.80
	5	01	0.11	0.91	13.00	3.00	8.00	3.80
		21	0.12	0.73	13.80	10.00	152.00	4.00
6	1	01	0.09	0.63	1.60	14.00	29.62	3.28
		05	0.25	5.42	10.00	0.84	6.89	8.00
	2	01	0.07	0.70	1.29	0.59	6.05	2.23
		15	0.06	0.95	1.19	1.48	5.74	1.76
	3	01	0.09	0.40	2.31	0.78	7.95	4.63
		20	0.09	0.46	1.44	0.53	12.25	2.33
	4	01	0.21	0.83	1.50	0.64	3.63	4.83
		18	0.05	0.39	2.32	0.59	8.47	2.47
	5	01	0.17	0.91	1.88	0.60	7.21	2.53
		22	0.15	2.58	3.63	0.43	3.63	0.77

APPENDIX V contd.

Section No.	Station No.	Depth (Meters)	Trace Metals (ppb) Cd	Pb	Cu	Cr	Zn	Mn
7	1	01	0.21	0.45	1.00	0.54	15.50	5.00
		04	1.83	0.50	0.60	0.90	1.80	1.20
	2	01	0.95	2.90	2.55	0.65	5.43	4.10
		14	1.55	1.40	2.60	0.80	15.00	1.90
	3	01	0.16	1.90	0.70	0.30	4.05	3.10
		19	0.70	0.25	1.80	0.70	10.51	1.50
	4	01	1.55	4.20	3.85	0.38	22.00	1.70
		16	0.30	1.10	5.30	7.80	24.50	1.80
	5	01	0.15	0.60	0.90	0.30	1.84	1.00
		21	2.70	8.50	10.00	0.40	23.00	1.80
8	1	01	0.41	0.30	1.30	0.60	20.90	1.90
		05	0.32	1.20	1.00	0.50	28.00	1.20
	2	01	0.30	0.50	1.30	0.38	18.00	2.20
		15	0.18	0.35	1.15	0.70	34.00	1.40
	3	01	0.23	1.50	4.10	82.00	11.00	4.30
		18	0.18	0.50	1.50	0.54	18.50	1.10
	4	01	0.85	0.20	1.00	0.54	31.00	1.20
		19	0.18	0.50	1.50	0.54	18.50	1.20
	5	01	0.41	0.30	1.30	0.60	11.50	1.20
		10	1.10	0.55	0.90	0.50	12.50	1.10
		23	0.15	0.70	1.00	0.60	7.00	1.10

APPENDIX VI

The observed concentration of selected trace metals in the sediments of the Escambia River, Perdido River, and the offshore territorial waters of Florida.

Sample No.	Trace Metal (ppm)										
	Hg	Ni	Fe	Mn	Cr	Zn	Co	Cu	Cd	Pb	Sn
C14	0.05	4.0	195	8.0	3.0	ND	5.0	1.0	1.0	6.0	12.0
C24	0.02	ND	460	7.0	5.0	1.0	4.0	1.0	ND	1.0	9.0
C25	0.04	2.0	429	6.0	4.0	1.0	4.0	1.0	ND	6.0	ND
C26	0.02	ND	500	24.0	3.0	4.0	4.0	1.0	1.0	11.0	6.0
C27	0.03	1.0	101	3.0	3.0	ND	5.0	1.0	ND	6.0	3.0
C28	0.01	ND	480	4.0	4.0	ND	2.0	2.0	ND	10.0	6.0
C29	0.42	18.0	656	78.0	49.0	96.0	28.0	18.0	ND	8.0	12.0
C30	0.28	9.0	671	45.0	34.0	60.0	9.0	10.0	1.0	13.0	6.0
C31	0.01	7.0	482	22.0	5.0	5.0	4.0	1.0	ND	6.0	9.0
C32	0.01	1.0	298	7.0	3.0	2.0	2.0	1.0	ND	3.0	3.0
C33	0.01	2.0	201	7.0	4.0	ND	2.0	2.0	ND	3.0	9.0
C34	0.01	3.0	464	17.0	5.0	2.0	8.0	ND	1.0	8.0	3.0
C35	0.01	ND	383	11.0	6.0	ND	2.0	ND	ND	1.0	ND
C36	ND	ND	189	6.0	4.0	ND	1.0	1.0	1.0	3.0	3.0
C38	0.03	80.0	606	81.0	15.0	27.0	122.0	21.0	1.0	1.0	3.0
C39	0.11	17.0	652	121.0	71.0	87.0	37.0	19.0	ND	6.0	9.0
C40	0.12	20.0	663	151.0	62.0	135.0	29.0	15.0	ND	8.0	9.0
C41	1.21	24.0	686	168.0	85.0	143.0	24.0	17.0	ND	8.0	9.0
C42	0.75	21.0	642	156.0	69.0	129.0	24.0	16.0	ND	3.0	9.0
C43	0.96	42.0	692	222.0	70.0	92.0	58.0	19.0	1.0	6.0	21.0
C44	0.11	19.0	692	207.0	67.0	105.0	15.0	15.0	1.0	6.0	12.0
C45	0.07	ND	627	65.0	15.0	58.0	2.0	6.0	1.0	1.0	3.0
C46	0.01	ND	627	64.0	18.0	25.0	4.0	4.0	ND	ND	9.0
C47	0.05	9.0	668	180.0	43.0	68.0	9.0	9.0	3.0	3.0	6.0

APPENDIX VI contd.

Sample No.	Trace Metal (ppm) Hg	Ni	Fe	Mn	Cr	Zn	Co	Cu	Cd	Pb	Sn
C48	0.04	ND	114	4.0	1.0	61.0	5.0	1.0	ND	3.0	6.0
C49	0.02	95.0	271	13.0	4.0	4.0	148.0	28.0	ND	6.0	ND
C51	0.01	5.0	343	13.0	3.0	ND	4.0	1.0	1.0	ND	6.0
C53	ND	ND	440	17.0	4.0	6.0	1.0	ND	ND	ND	3.0
C54	0.01	2.0	524	26.0	4.0	8.0	2.0	1.0	ND	ND	6.0
C56	0.02	3.0	405	18.0	6.0	3.0	4.0	ND	ND	1.0	3.0
C57	0.01	ND	382	9.0	3.0	ND	2.0	ND	ND	ND	3.0
C60	ND	9.0	585	65.0	7.0	15.0	16.0	3.0	1.0	ND	ND
C61	0.01	ND	435	31.0	7.0	1.0	2.0	ND	ND	ND	ND
C62	0.02	10.0	447	15.0	6.0	29.0	11.0	3.0	ND	1.0	ND
C67	0.02	12.0	254	6.0	1.0	ND	24.0	ND	ND	6.0	ND
C68	0.01	5.0	183	5.0	2.0	ND	2.0	1.0	ND	6.0	ND
C69	ND	ND	307	29.0	3.0	ND	9.0	3.0	ND	ND	6.0
C70	0.02	3.0	486	32.0	3.0	3.0	1.0	1.0	4.0	1.0	9.0
C71	ND	5.0	385	9.0	3.0	4.0	9.0	1.0	4.0	3.0	6.0
C72	ND	1.0	462	18.0	1.0	ND	2.0	1.0	ND	3.0	ND

APPENDIX VII

The observed concentrations of selected pesticides of the territorial waters of Florida offshore from ESCAROSA.

Section No.	Station No.	Depth (Meters)	Pesticides (ppt) pp'DDT	pp'DDE	pp'TDE	op'DDT	DDE	TDE	Dieldrin	Endrin	Aldrin	Heptachlor Epoxide	PCB Arochlore
20	1	01	ND	1.7	ND	ND	ND	6.9	ND		ND	ND	
		05	ND	ND	ND	ND	ND	ND	3.9		ND	ND	
	2	01	9.5	ND	ND	2.5	ND	ND	35.0		ND	ND	
			*	3.3	ND	ND	3.0	ND	*			ND	
		09	ND	ND	ND	ND	ND	ND	4.4		ND	ND	
	3	01	3.6	ND	ND	3.7	ND	ND	14.4		ND	ND	
		12	ND	ND	1.9	ND	ND	ND	8.7		ND	ND	
	4	01	ND	ND	ND	ND	ND	ND	ND		ND	ND	
		15	ND	ND	ND	ND	ND	ND	25.9		ND	ND	
	5	01	ND	ND	ND	ND	ND	ND	19.6		ND	ND	
		15	ND	ND	ND	ND	ND	ND	8.6		ND	ND	
			*Peak off scale; sample will be rerun at lower sensitivity.										
19	1	01	ND	ND	ND	ND	ND	ND	6.0		ND	ND	
									ND		ND		
		09	ND	ND	ND	ND	ND	ND	ND		ND	ND	
	2	01	ND	ND	ND	ND	ND	ND	13.9		ND	ND	
			ND	ND	ND	ND	ND	ND	ND		ND	ND	
		08	ND	ND	ND	ND	ND	ND	ND		ND	ND	
	3	01	ND	ND	ND	ND	ND	ND	ND		ND	ND	
		12	ND	ND	ND		13.8	ND	34.5		ND	ND	
			34.5	ND	ND	31.5	ND	37.5	22.6		19.0	ND	
	4	01	ND	ND	ND	ND			6.8		ND	ND	
						ND			13.0		ND		
		13	25.2	ND	ND	30.9	ND	30.2	20.5		17.2	ND	
	5	01	ND	ND	ND	ND	ND	ND	ND		ND	ND	
		19	ND	ND	ND	ND	ND	ND	ND		ND	ND	

APPENDIX VII contd.

Section No.	Station No.	Depth (Meters)	Pesticides (ppt) pp'DDT	pp'DDE	pp'TDE	op'DDT	DDE	TDE	Dieldrin	Endrin	Aldrin	Heptachlor Epoxide	PCB Arochlore
18	1	01	ND	ND	ND	40.5	ND	33.3	ND		ND	ND	
		07	ND	ND	ND	47.6	ND	38.1	ND		ND	ND	
	2		No samples taken.										
	3	01	ND	ND	ND	ND	ND	ND	ND		ND	ND	1248
		12	ND	ND	ND	ND	ND	ND	ND		ND	ND	1254
													1248
													1260
	4	01	ND	ND	ND	ND	ND	ND	ND		ND	ND	Composite
		13	ND	ND	ND	ND	ND	ND	ND		ND	ND	Composite
	5	01	ND	ND	ND	ND	ND	ND	6.8		ND	ND	
			ND	ND	ND	ND	14.3	ND	9.5		ND	6.0	
		15	309.5	28.6	40.5	255.9	ND	23.8	28.6		ND	ND	
17	1	01	3.1	ND	ND	ND	ND	ND	ND		ND	ND	
		06	ND	ND	ND	ND	ND	ND	ND		ND	7.1	
	2	01	ND	7.1	ND	76.2	11.9	50.0	ND		ND	4.8	
		10	ND	ND	ND	ND	ND	32.1	16.7		ND	ND	
	3	01	ND	ND	ND	ND	ND	ND	71.4		ND	ND	
		13	ND	4.8	ND	28.6	ND	19.0	ND		ND	4.8	
	4	01	ND	ND	ND	ND	ND	ND	ND		ND	ND	
		16	ND	ND	ND	38.0	ND	42.9	ND		ND	ND	
	5	01	ND	4.8	ND	ND	11.9	ND	9.8		ND	7.1	
		21	ND	ND	ND	ND	7.1	16.7	4.8		ND	ND	
16	1	01	ND	ND	ND	ND	ND	ND	14.3		ND	ND	
		07	ND	ND	ND	ND	ND	11.9	9.5		ND	7.1	
	2	01	ND	ND	ND	ND	11.9	ND	11.9		ND	4.8	
		09	2.1	ND	ND	ND	ND	ND	ND		ND	ND	
	3	01	ND	ND	ND	23.8	ND	26.2	ND		ND	ND	
		13	ND	ND	ND	42.9	ND	79.8	ND		ND	ND	
	4	01	ND	ND	ND	28.6	ND	28.6	ND		ND	ND	
		15	ND	ND	ND	42.9	11.9	95.2	9.5		ND	7.1	

APPENDIX VII contd.

Section No.	Station No.	Depth (Meters)	Pesticides (ppt) pp'DDT	pp'DDE	pp'TDE	op'DDT	DDE	TDE	Dieldrin	Endrin	Aldrin	Heptachlor Epoxide	PCB Arochlore
	5	01	ND	ND	28.6	138.0	ND	71.4	9.5		ND	ND	
		21	ND	ND	42.7	42.8	ND	47.6	ND		ND	ND	
15	1	01	ND	ND	ND	ND	ND	ND	ND		ND	ND	Arochlores
		06	ND	ND	ND	ND	ND	ND	ND		ND	ND	Arochlores
	2	01	ND	ND	ND	16.7	ND	14.3	6.0		ND	2.4	
		12	ND	ND	ND	76.2	ND	45.2	ND		ND	ND	
	3	01	ND	ND	ND	ND	ND	ND	2.4		ND	8.3	
		18	ND	ND	ND	ND	ND	ND	ND		ND	ND	Composite
	4	01	ND	ND	ND	ND	ND	ND	ND		ND	ND	
		23	ND	ND	ND	ND	11.9	ND	4.8		ND	7.1	
	5	01	ND	ND	ND	ND	7.1	ND	4.8		ND	4.8	
		22	ND	ND	ND	ND	ND	ND	ND		ND	ND	
14	1	01	ND	ND	ND	ND	ND	ND	ND		ND	ND	
		06	ND	ND	ND	ND	ND	ND	ND		ND	ND	Arochlores
	2	01	ND	ND	ND	ND	ND	ND	7.1		ND	ND	
		10	ND	ND	ND	ND	ND	ND	ND		ND	ND	1254
	3	01	ND	ND	ND	ND	ND	ND	ND		ND	ND	1254 (0.35)
		15	ND	ND	ND	ND	ND	ND	ND		ND	ND	Arochlores
	4	01	ND	ND	ND	ND	ND	ND	ND		ND	ND	Arochlores
		21	ND	ND	ND	ND	ND	ND	ND		ND	ND	Arochlores
	5	01	ND	ND	ND	ND	ND	ND	ND		ND	ND	Arochlores
		23	ND	ND	ND	ND	ND	ND	ND		ND	ND	Arochlores
13	1	01	30.9	1.9	5.9	3.5	ND	ND	23.9		ND	ND	
		07	ND	ND	ND	ND	ND	ND	8.9		ND	ND	
	2	01	ND	ND	ND	ND	ND	ND	8.1		ND	ND	
		12	ND	ND	ND	ND	ND	ND	29.9		ND	ND	
	3	01	ND	ND	1.9	ND	ND	ND	3.3		ND	ND	
		15	ND	ND	ND	ND	ND	ND	ND		ND	ND	

APPENDIX VII contd.

Section No.	Station No.	Depth (Meters)	Pesticides (ppt) pp'DDT	pp'DDE	pp'TDE	op'DDT	DDE	TDE	Dieldrin	Endrin	Aldrin	Heptachlor Epoxide	PCB Arochlore
	4	01	ND	ND	ND	ND	ND	ND	9.5		ND	ND	
		17	ND	ND	ND	ND	ND	ND	5.7		ND	ND	
	5	01	ND	ND	ND	ND	ND	ND	9.5		ND	ND	
		19	ND	ND	ND	ND	ND	ND	2.4		ND	ND	
1	1	01	ND	ND	ND	ND	ND	ND	23.4		ND	18.6	
		05	ND	ND	ND	ND	19.8	ND	23.6		ND	18.9	
	2	01	ND	ND	ND	ND	2.14	ND	19.8	ND	ND	ND	
			ND	ND	ND	ND	ND	ND	20.2	ND	ND	ND	
		15	ND	ND	ND	ND	ND	ND	4.5	ND	ND	ND	
			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
	3	01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
		21	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
	4	01	ND	ND	ND	ND	ND	ND	5.0	ND	ND	ND	
			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
		18	ND	ND	ND	ND	ND	ND	11.9	ND	ND	2.4	
			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
	5	01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
		22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
12	1	01	ND	ND	4.3	ND	ND	ND	7.4		ND	ND	
		09	1.8	ND	3.1	ND	ND	ND	16.8		ND	ND	
	2	01	ND	ND	ND	ND	ND	ND	2.3		ND	ND	
		15	ND	ND	ND	ND	ND	ND	18.1		ND	ND	
	3	01	6.8	2.8	3.0	3.3	2.0	ND	12.3		ND	ND	
		19	ND	ND	2.1	ND	ND	ND	7.1		ND	ND	
		01	1.7	ND	3.1	ND	ND	ND	21.8		ND	ND	
		22	ND	ND	ND	ND	ND	ND	6.7		ND	ND	
	5	01	ND	ND	ND	ND	ND	ND	4.4		ND	ND	
		24	ND	ND	ND	1.4	ND	ND	11.4		ND	ND	

APPENDIX VII contd.

Section No.	Station No.	Depth (Meters)	Pesticides (ppt) pp'DDT	pp'DDE	pp'TDE	op'DDT	DDE	TDE	Dieldrin	Endrin	Aldrin	Heptachlor Epoxide	PCB Arochlore
11	1	01	ND	ND	ND	ND	ND	ND	ND		ND	ND	
		09	ND	ND	ND	ND	ND	ND	3.1		ND	ND	
	2	01	3.1	ND	ND	ND	ND	ND	11.8		ND	ND	
		19	ND	ND	ND	ND	ND	ND	7.9		ND	ND	
	3	01	ND	ND	ND	ND	ND	ND	16.3		ND	ND	
		23	ND	ND	ND	ND	ND	ND	12.0		ND	ND	
	4	01	ND	ND	ND	ND	ND	ND	5.2		ND	ND	
		25	ND	ND	ND	ND	ND	ND	8.1		ND	ND	
	5	01	2.4	ND	ND	ND	ND	ND	15.5		ND	ND	
		25	ND	ND	ND	ND	ND	ND	10.4		ND	23.2	
10	1	01	ND	ND	ND	ND	ND	ND	24.8		ND	ND	
		10	ND	ND	ND	ND	ND	ND	8.7		ND	ND	
	2	01	ND	ND	ND	ND	ND	ND	6.4		ND	ND	
		26	ND	1.8	2.4	2.4	ND	ND	10.5		ND	ND	
	3	01	ND	ND	ND	ND	ND	ND	24.8		ND	ND	
		24	8.6	2.4	4.5	4.8	5.4	ND	23.3		ND	2.3	
	4	01	ND	2.7	1.3	2.8	ND	ND	9.6	ND	ND	1.4	
		24	2.9	ND	ND	ND	ND	10.5	ND		ND	ND	
			10.2	4.2	ND	6.9	ND	16.9	7.0		ND	ND	
	5	01	ND	4.5	ND	ND		6.3	3.6		ND	ND	
			4.6	7.7	ND	6.9	ND	11.0	20.5		ND	2.0	
		26	26.8	ND	ND	ND	ND	ND	ND		ND	ND	
9	1	01	14.2	4.7	3.6	3.8	ND	ND	2.4		ND	ND	
		11	ND	5.2	ND	3.0	ND	12.5	ND			ND	
	2	01	2.0	5.5	ND	7.9	ND	11.7	18.9		ND	ND	
			10.1	10.1	ND	7.6	ND	23.3	13.9		ND	1.7	
		18	6.3	10.2	ND	7.3	ND	10.4	18.2		1.3	ND	
	3	01	2.2	ND	ND	1.9	ND	1.9	4.0		ND	2.1	
		19	ND	ND	ND	ND	ND	ND	6.2		ND	ND	
			ND	ND	ND	ND	ND	ND	12.5		ND	ND	

APPENDIX VII contd.

Section No.	Station No.	Depth (Meters)	Pesticides (ppt) pp'DDT	pp'DDE	pp'TDE	op'DDT	DDE	TDE	Dieldrin	Endrin	Aldrin	Heptachlor Epoxide	PCB Arochlore
	4	01	ND	7.1	ND	3.9	ND	11.1	1.9		ND	ND	
		20	19.9	34.0	ND	29.3	ND	55.2	ND		ND	ND	
			35.7	37.4	ND	33.9		54.8	13.7			ND	
	5	01	4.5	ND	1.9	ND	ND	ND	19.2		ND	ND	
		24	ND	ND	ND	ND	ND	ND	19.0		ND	ND	
						R/V TURSIOPS TIME SERIES							
1	1	01	ND	ND	ND	ND	ND	ND	23.4		ND	18.6	
		05	ND	ND	ND	ND	19.8	ND	23.6		ND	18.9	
	2	01	ND	ND	ND	ND	2.14	ND	19.8	ND	ND	ND	
			ND	ND	ND	ND	ND	ND	20.2	ND	ND	ND	
		15	ND	ND	ND	ND	ND	ND	4.5	ND	ND	ND	
	3	01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
		21	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
	4	01	ND	ND	ND	ND	ND	ND	5.0	ND	ND	ND	
			ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
		18	ND	ND	ND	ND	ND	ND	11.9	ND	ND	2.4	
			ND	ND	ND	ND	ND	ND	ND			ND	
	5	01	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
		22	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
2	1	01	ND	ND	ND	ND	ND	ND	5.5		ND	ND	
					ND	ND	ND		13.2			ND	
		11	2.4	ND	ND	ND	9.0	ND	11.9		ND	ND	
			ND	ND	ND	ND	ND	ND	13.0		ND	ND	
3	1	01	ND	ND	ND	2.8	ND	24.5	ND		ND	ND	
			ND	ND	27.5	22.0	20.3		20.0		16.5	ND	
			5.2	ND	ND	ND	3.1		12.9		13.6	2.6	
		05	ND	ND	30.0	25.4	21.0	26.3	2.9		17.2	ND	
									21.2				

APPENDIX VII contd.

R/V TURSIOPS TIME SERIES

Section No.	Station No.	Depth (Meters)	Pesticides (ppt) pp'DDT	pp'DDE	pp'TDE	op'DDT	DDE	TDE	Dieldrin	Endrin	Aldrin	Heptachlor Epoxide	PCB Arochlore
4	1	01	6.3	ND	ND	21.5	2.9	ND	11.1		17.0	ND	
			ND				ND	26.0	20.0			ND	
		05	ND	ND	ND	20.0	ND	18.6	27.6		ND	18.6	
	2	01	ND	ND	ND	ND	ND	ND	ND		ND	ND	
		13	ND	ND	ND	ND	ND	ND	35.0		ND	ND	
			11.6	15.6	ND	13.8	ND	28.2	16.6		ND	ND	
	3	01	ND	ND	ND	ND	ND	ND	2.4		ND	ND	
		20	1.7	0.8	5.7	ND	ND	ND	10.4		ND	ND	
	4	01	ND	ND	ND	7.6	ND	ND	ND		ND	ND	
		18	ND	ND	ND	6.0	ND	ND	ND		ND	ND	
	5	01	ND	1.6	5.2	ND	ND	ND	2.9	ND	ND	ND	
		22	ND	ND	ND	ND	ND	ND	ND		ND	ND	
5	1	01	ND	ND	ND	ND	ND	ND	6.5		ND	6.0	
		05	2.6	ND	ND	ND	3.6	ND	2.2		ND	2.1	
6	1	01	10.6	ND	ND	ND	ND	ND	11.2		ND	ND	
			ND						ND		ND	ND	
		05	ND	ND	ND	ND	ND	ND	9.0		ND	ND	
									ND		ND	ND	
7	1	01	3.6	ND	ND	1.9	ND	ND	ND		ND	ND	
		04	9.5	10.0	ND	10.1	ND	19.5	ND		ND	ND	
8	1	01	*	ND	ND	ND	ND	ND	5.4	ND	ND	ND	
		05	2.1	ND	ND	ND	ND	ND	1.9		ND	ND	
			ND	ND	4.5	ND	1.7	ND	9.0		4.8	ND	

*Peaks off-scale; sample will be rerun at lower sensitivity.

APPENDIX VII contd.

R/V TURSIOPS TIME SERIES

Section No.	Station No.	Depth (Meters)	Pesticides (ppt) pp'DDT	pp'DDE	pp'TDE	op'DDT	DDE	TDE	Dieldrin	Endrin	Aldrin	Heptachlor Epoxide	PCB Arochlore
	3	01	19.1	10.7	9.5	16.1	ND	24.1	8.6		1.1	2.6	
		18	15.9	21.3	ND	20.0	ND	36.7	2.6		ND	ND	
			31.1	19.2	3.2	21.7	19.2	59.0	ND		ND	1.2	
	5	01	6.7	5.8	ND	10.1	ND	17.1	4.8		ND	ND	
			13.2	10.2	ND	13.4	1.1	21.4	13.4		1.6	5.2	
		22	ND	ND	ND	5.5	ND	13.8	ND		ND	ND	
			10.2	6.9	ND	6.9	2.0	17.1	5.5		ND	1.5	